Final Recovery Plan for the

Shortnose Sturgeon

Acipenser brevirostrum

December 1998

U.S. Department of Commerce

National Oceanic and
Atmospheric Administration

National Marine Fisheries Service

Final Recovery Plan for the

Shortnose Sturgeon

(*Acipenser brevirostrum*)

prepared by the

Shortnose Sturgeon Recovery Team

for the

National Marine Fisheries Service
National Oceanic and Atmospheric Administration

December 1998

Approved: ____

Rolland A. Schmitten
Assistant Administrator for Fisheries
National Marine Fisheries Service
National Oceanic and Atmospheric Administration

Disclaimer

This recovery plan for the shortnose sturgeon has been approved by the National Marine Fisheries Service. It does not necessarily represent official positions or approvals of cooperating agencies nor the views of all individuals involved in the plan's formulation. The National Marine Fisheries Service has determined that the information used in the development of this document represents the best scientific and commercial data available at the time it was written. The Recovery Plan was prepared by the Shortnose Sturgeon Recovery Team to delineate reasonable actions that will promote recovery of the shortnose sturgeon. This plan is subject to modification as dictated by new findings, changes in species status, and completion of tasks described in the plan. Goals and objectives will be attained and funds expended contingent upon agency appropriations and priorities.

Literature Citations should read as follows:

National Marine Fisheries Service. 1998. Recovery Plan for the Shortnose Sturgeon (*Acipenser brevirostrum*). Prepared by the Shortnose Sturgeon Recovery Team for the National Marine Fisheries Service, Silver Spring, Maryland. 104 pages.

Preface

Congress passed the Endangered Species Act of 1973 (16 USC 1531 *et seq*, amended 1978, 1982, 1986, 1988) (ESA) to protect species of plants and animals endangered or threatened with extinction. The National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (FWS) share responsibility for the administration of the Endangered Species Act. The NMFS is responsible for most marine and anadromous species including the shortnose sturgeon.

Section 4(f) of the ESA directs the responsible federal agency to develop and implement a recovery plan, unless such a plan would not promote the conservation of a species. The NMFS determined that a recovery plan would promote conservation and recovery of shortnose sturgeon. The Shortnose Sturgeon Recovery Team included shortnose sturgeon experts from state and federal government and the private sector.

The NMFS agrees with the Shortnose Sturgeon Recovery Team in that the goals and objectives of this recovery plan can be achieved only if a long-term commitment is made to support the actions recommended here. Achieving these goals and objectives will require the cooperation of state and federal government agencies.

Shortnose Sturgeon Recovery Team:

Jeff Brown, NMFS, Southeast Regional Office, St. Petersburg, Florida

Kevin Friedland, NMFS, Northeast Science Center, Woods Hole, Massachusetts

Nancy Haley, (Team Leader) NMFS, Northeast Region, Milford, Connecticut

Boyd Kynard, BRD/USGS, Conte Anadromous Fish Research Laboratory, Turners Falls, Massachusetts

Margaret Lorenz (Team Advisor), NMFS, Office of Protected Resources, Silver Spring, Maryland

Mary Moser (Team Leader), Center for Marine Science Research, University of North Carolina-Wilmington, Wilmington, North Carolina

Marta Nammack (Team Advisor), NMFS, Office of Protected Resources, Silver Spring, Maryland

Gordon Rogers, Satilla Management Associates/Southern Resources and Environmental Services, Brunswick, Georgia

Tom Squiers, Maine Department of Marine Resources Augusta, Maine

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List of Abbreviations

ACOE	U.S. Army Corps of Engineers
ASMFC	Atlantic States Marine Fisheries Commission
BL	Body Length
CI	Confidence Interval
DPS	Distinct Population Segment
EPA	Environmental Protection Agency
ESA	Endangered Species Act
FER	Federal Energy Regulatory Commission
FHWA	Federal Highway Administration
FL	Fork Length
FWS	U.S. Fish and Wildlife Service
NMFS	National Marine Fisheries Service
NRC	Nuclear Regulatory Commission
PIT	Passive Integrated Transponder
SL	Standard Length
SSRT	Shortnose Sturgeon Recovery Team
TL	Total Length
YOY	Young of the Year

Executive Summary

Current Species Status: The shortnose sturgeon (*Acipenser brevirostrum*) was listed as endangered on March 11, 1967 (32 FR 4001). Shortnose sturgeon remained on the endangered species list with enactment of the ESA in 1973. Although originally listed as endangered rangewide, the NMFS recognizes 19 distinct population segments occurring in New Brunswick, Canada (1), Maine (2), Massachusetts (1), Connecticut (1), New York (1), New Jersey/Delaware (1), Maryland/Virginia (1), North Carolina (1), South Carolina (4), Georgia (4) and Florida (2).

Habitat Requirements and Limiting Factors: Shortnose sturgeon inhabit the main stems of their natal rivers, migrating between freshwater and mesohaline river reaches. Spawning occurs in upper, freshwater areas, while feeding and overwintering activities may occur in both fresh and saline habitats. Habitat degradation or loss (resulting, for example, from dams, bridge construction, channel dredging, and pollutant discharges), and mortality (for example, from impingement on cooling water intake screens, dredging, and incidental capture in other fisheries) are principal threats to the species' survival.

Recovery Goal: To delist shortnose sturgeon populations throughout their range.

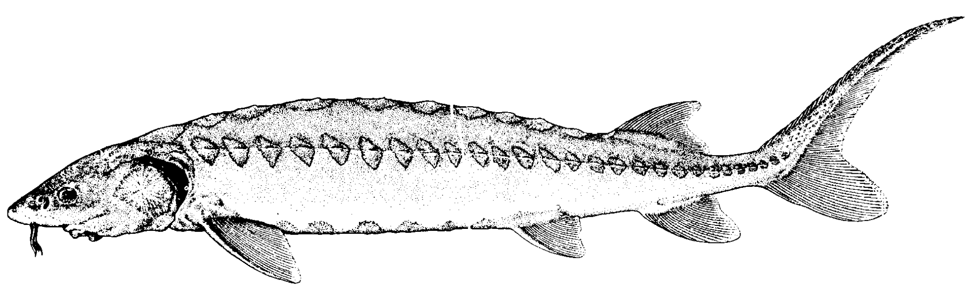
Recovery Objective and Criteria: To recover populations to levels of abundance at which they no longer require protection under the ESA. For each population segment, the minimum population size will be large enough to maintain genetic diversity and avoid extinction.

Actions Needed:

1. Establish Listing Criteria for Shortnose Sturgeon Population Segments
2. Protect Shortnose Sturgeon and their Habitats
3. Rehabilitate Shortnose Sturgeon Populations and Habitats
4. Implement Recovery Tasks

Cost of Recovery Tasks: The costs of recovery are undeterminable at this time. Refer to the Implementation Schedule for cost estimates for individual tasks. Cost estimates were not available for some tasks because the actual actions needed are not known (for example: costs of restoring access to spawning areas located above dams will vary depending on the type of fish passage implemented). In addition, some tasks are a high priority for a large number of population segments. If these tasks are conducted on several rivers concurrently, costs may be significantly reduced. Therefore, accurate cost estimates were impossible to predict.

Date of Recovery: There is evidence that some population segments are already starting to recover. Delisting of all population segments could be initiated by 2024, if all recovery criteria are met.



Shortnose sturgeon (*Acipenser brevirostrum*)

INTRODUCTION

The shortnose sturgeon, *Acipenser brevirostrum*, is an endangered fish species that occurs in large coastal rivers of eastern North America. The NMFS recognizes 19 distinct population segments of shortnose sturgeon inhabiting 25 river systems ranging from the Saint John River in New Brunswick, Canada, to the St. Johns River, Florida (Table 1). The criterion used by the Shortnose Sturgeon Recovery Team (SSRT) to identify these systems was the capture of a shortnose sturgeon in a river/estuarine system within the generation time of the species (30 years). Of the river systems for which population estimates are available, the smallest number of adult fish (< 100 adults) occur in the Merrimack (Massachusetts) and Cape Fear (North Carolina) rivers while the largest number inhabit the Hudson (New York) (>38,000) and Saint John (New Brunswick) rivers (~18,000 adults). Throughout this recovery plan reference is made to "northeast" and "southeast" sturgeon populations. These geographic references follow the respective jurisdictional ranges of the NMFS' Northeast and Southeast regions. All populations from the Chesapeake Bay north are considered "northeast" while those south of the Bay are considered "southeast" population segments.

Legislative Background

Shortnose sturgeon were originally listed as an endangered species by the FWS on March 11, 1967 under the Endangered Species Preservation Act (32 FR 4001, Appendix I). The NMFS later assumed jurisdiction for shortnose sturgeon under a 1974 government reorganization plan (38 FR 41370). Although the original listing notice did not cite reasons for listing the species, a 1973 Resource Publication (Appendix II), issued by the U.S. Department of Interior, stated that shortnose sturgeon were Ain peril ... gone in most of the rivers of its former range [but] probably not as yet extinct" (USDOI 1973). Pollution and overfishing, including bycatch in the shad fishery, were listed as principal reasons for the species' decline. In the late nineteenth and early twentieth centuries shortnose sturgeon commonly were taken in a commercial fishery for the

Table 1. Shortnose Sturgeon Population Segments

Distinct Population Segments:	**Rivers Inhabited by Shortnose Sturgeon**
Saint John	Saint John River (New Brunswick, Canada)
Penobscot	Penobscot River (Maine)
Kennebec System	Sheepscot, Kennebec, and Androscoggin Rivers (Maine)
Merrimack	Merrimack River (Massachusetts)
Connecticut	Connecticut River (Massachusetts and Connecticut)
Hudson	Hudson River (New York)
Delaware	Delaware River (New Jersey, Delaware. Pennsylvania)
Chesapeake Bay	Chesapeake Bay, Potomac River (Maryland and Virginia)
Cape Fear	Cape Fear River (North Carolina)
Winyah Bay	Waccamaw, Pee Dee and Black Rivers (South Carolina, North Carolina)
Santee	Santee River (South Carolina)
Cooper	Cooper River (South Carolina)
"ACE" Basin	Ashepoo, Combahee and Edisto Rivers (South Carolina)
Savannah	Savannah River (South Carolina, Georgia), and hatchery stocks
Ogeechee	Ogeechee River (Georgia)
Altamaha	Altamaha (Georgia)
Satilla	Satilla River (Georgia)

Distinct Population Segments:	Rivers Inhabited by Shortnose Sturgeon
St. Marys	St. Marys River (Florida)
St. Johns	St. Johns River (Florida)

closely related, and commercially valuable, Atlantic sturgeon (*Acipenser oxyrinchus*). Catch statistics did not differentiate the two species. Some mis-identifications occurred (Ross et al. 1988) because, at smaller sizes, Atlantic sturgeon are easily confused with shortnose sturgeon unless diagnostic features are recognized. Since there are few confirmed historical reports of shortnose sturgeon captures and because fishermen and scientists did not distinguish between the two species in scientific reports and landing records, there are no reliable estimates of historical population sizes.

More than a century of extensive fishing for sturgeon contributed to the decline of Atlantic and shortnose sturgeon populations along the east coast. Heavy industrial development during the twentieth century in rivers inhabited by sturgeon impaired water quality and impeded these species' recovery; possibly resulting in substantially reduced abundance of shortnose sturgeon populations within portions of the species' ranges (e.g., southernmost rivers of the species range: Satilla, St. Marys, and St. Johns Rivers).

Congress passed the ESA to provide protection for species threatened with extinction. Pursuant to Section 4(f)(1) of the ESA, the NMFS and the FWS are required to develop and implement recovery plans "for the conservation and survival of endangered species and threatened species" unless a recovery plan would not help to promote species conservation. Highest priority is given to those species that are or may be in conflict with development projects or other commercial activities. Shortnose sturgeon spend their entire life in waters that are heavily impacted by various construction and industrial activities. Hence, there is a definite need for a recovery plan that comprehensively addresses these factors and describes ways to mitigate or minimize harm to shortnose sturgeon populations rangewide. Moreover, many federal agencies authorize, fund, or carry out actions in rivers where sturgeon occur and, left unchecked, these activities could be detrimental to population survival. This Recovery Plan provides a framework for addressing a multitude of biological concerns, and outlines federal agency responsibilities under the ESA, with the sole purpose of insuring long-term survival of the shortnose sturgeon.

Chronology of Shortnose Sturgeon Recovery Activities

The first step of more than 30 years of shortnose sturgeon recovery began when the FWS placed the species on the original Endangered Species List in 1967. Citing pollution and overfishing as reasons for the shortnose sturgeon's alleged decline, the species continued to meet the criteria of "endangered" under subsequent definitions specified in the 1969 Endangered Species Conservation Act, and in the Endangered Species Act passed in 1973. In 1977, the NMFS established the first SSRT to complete a recovery plan for the species. Although a draft Shortnose Sturgeon Recovery Plan was prepared by this team in 1981, the draft was never forwarded for approval to the Assistant Administrator for Fisheries. Instead, the NMFS elected to complete a Status Review for shortnose sturgeon prior to publishing a final recovery plan.

A Shortnose Sturgeon Status Review was drafted in 1987 and stands as the most recent assessment of the species' status. The most significant conclusions of the 1987 Status Review were recommendations to change the status of the Connecticut, Delaware, and Hudson River populations to "threatened," to delist the Kennebec River system population, and to consider each shortnose sturgeon population as a distinct unit under the ESA definition of "species." The 1987 Status Review states that: "the differences reported in longevity, growth rates, and age at sexual maturity between shortnose sturgeon from the northern and southern extremes of its range are expected in any species with a wide latitudinal distribution. The best available information also indicates differences in life history and habitat preferences between northern and southern river systems (Dadswell et al. 1984), although there are no genetic or morphometric data available to support any taxonomic splitting of the species. However, given the species' anadromous breeding habits, it is unlikely that populations in adjacent river systems interbreed with any regularity. Therefore, until interbreeding is confirmed, we will consider each population within a river system to be a distinct unit under the ESA definition of "species"."

The NMFS received comments on the 1987 Status Review and convened a second SSRT in 1988 to critically review the document and report its findings to the NMFS. This team disbanded before a report was completed. After 5 years of no activity beyond mandated management under Section 7 of the ESA, the NMFS gathered a third SSRT in 1993 to complete the long-awaited Shortnose Sturgeon Recovery Plan.

Recovery Plan

This Recovery Plan was drafted by a seven-member recovery team comprising staff from federal, state and private institutions with both fishery research and management backgrounds (see Preface). In addition, the SSRT solicited the assistance of a group of "Technical Advisors" (see Acknowledgments) with diverse expertise in sturgeon research and management and species recovery planning. The Recovery Plan contains four main sections: 1) an updated synopsis of the biology and distribution of shortnose sturgeon; 2) a description of factors affecting species recovery; 3) an outline of actions needed to recover shortnose sturgeon; and 4) a detailed implementation schedule for completing specific recovery tasks. This Recovery Plan will be periodically revised by the NMFS or a NMFS-appointed plan implementation team to reflect new scientific findings, reclassification and recovery of individual population segments, and improved understanding of factors affecting population survival.

Recovery Approach

Defining what it means to "recover" shortnose sturgeon is complicated by the lack of information on historical population levels and rangewide genetic variation. Shortnose sturgeon are known to have existed in a number of rivers where they no longer occur, particularly in the middle, and at

the southern end of their range. This plan primarily addresses recovery of extant shortnose sturgeon population segments. While, recovery actions to restore shortnose sturgeon in rivers where they historically occurred are considered a relatively low priority, the NMFS recognizes the importance of restoring the historically continuous range of the species to re-establish minimal gene flow. A sampling protocol will be developed to determine the minimum amount of sampling needed to establish the presence of shortnose sturgeon in a river system. When sampling is sufficient to establish that shortnose sturgeon are unlikely to exist in a river where they historically occurred, then the list of distinct population segments (Table 1) may require revision.
A joint NMFS/FWS policy (61 FR 4722, February 7, 1996) recognizes distinct vertebrate population segments (DPS) of a species on the basis of: 1) discreteness, 2) significance to the rest of the species, and 3) conservation status. The SSRT defined DPSs of shortnose sturgeon without the benefit of genetic information, however, this information is needed to help resolve DPSs with greater accuracy (61 FR 4722, February 7, 1996). For example, genetic information is needed to determine whether interbreeding occurs between rivers that drain into a common estuary (e.g., Kennebec and Androscoggin Rivers, ACE Basin). At this time, such river systems are considered a single population segment comprised of breeding subpopulations. Genetic data may indicate that the individual rivers in such systems support distinct population segments.

Although genetic variation within and among shortnose sturgeon occurring in different river systems is not known, life history studies indicate that shortnose sturgeon populations from different river systems are substantially reproductively isolated (Kynard 1997) and, therefore, should be considered discrete. Shortnose sturgeon are known to occur in 19 different river systems from New Brunswick to Florida. While their biology and movement patterns have been studied to varying degrees in each system, differences in life history and migratory patterns have been confirmed on at least a regional basis. For example, shortnose sturgeon grow faster in the south but attain larger adult sizes at the northern part of their range. Seasonal movement patterns and spawning locations of shortnose sturgeon also appear to vary with latitude. In northern rivers fish move to estuarine locations in summer, presumably to feed on seasonally abundant invertebrate prey. Estuarine residence in southern rivers, which occurs in winter, appears to last longer. Finally, numerous tagging and telemetry studies have been undertaken to better understand shortnose sturgeon habitat use and seasonal distribution patterns throughout their range. Few recaptures of tagged fish in adjacent river systems have ever been documented, and available tagging data suggest that migration between river systems is low compared to other anadromous species.

Based on the above biological and ecological differences and the lack of recaptures of sturgeon from adjacent river systems, the NMFS concurs with the SSRT and considers shortnose sturgeon from different river systems to be substantially reproductively isolated. The loss of a single shortnose sturgeon population segment may risk the permanent loss of unique genetic information that is critical to the survival and recovery of the species. Therefore, each shortnose sturgeon population should be managed as a distinct population segment for the purposes of Section 7 of the ESA. Under this policy, actions that could adversely affect a DPS will be evaluated in terms of their potential to jeopardize the continued existence of an individual population segment (as opposed to the existence of shortnose sturgeon rangewide).

NOMENCLATURE AND TAXONOMY

Nomenclature

The scientific name for the shortnose sturgeon is *Acipenser brevirostrum*. *Acipenser* is latin for sturgeon and *brevirostrum* means short snout. LeSueur originally described the species from a specimen taken from the Delaware River (Dadswell et al. 1984). Vernacular names include shortnosed sturgeon, little sturgeon (Saint John River, N.B.), pinkster and roundnoser (Hudson River), bottlenose or mammose (Delaware River), salmon sturgeon (Carolinas), and soft-shell or lake sturgeon (Altamaha River) (Dadswell et al. 1984).

Taxonomy

Class: Osteichthyes
Order: Acipenseriformes
Family: Acipenseridae
Genus: Acipenser
Species: brevirostrum

<u>Type Specimen</u>

The holotype was collected from the Delaware River and is housed at the Academy of Natural Sciences of Philadelphia, ANSP 16953 (Dadswell et al. 1984).

<u>Current Taxonomic Treatment</u>

The shortnose sturgeon is a member of the family Acipenseridae, which occurs in the Northern Hemisphere. In the United States this family inhabits the Atlantic and Pacific Oceans, the Gulf of Mexico, and certain freshwater systems (Nelson 1984). In North America the family is represented by five members of the genus *Acipenser* and three members of the genus *Scaphirhynchus*.

The other sturgeon likely to be found in the same waters as the shortnose sturgeon is the Atlantic sturgeon, *Acipenser oxyrinchus*. Adult and juvenile shortnose sturgeon may be distinguished from the Atlantic sturgeon on the basis of mouth width versus interorbital width, scute patterns, and snout length (Vladykov and Greeley 1963; Scott and Crossman 1973) (Table 2).

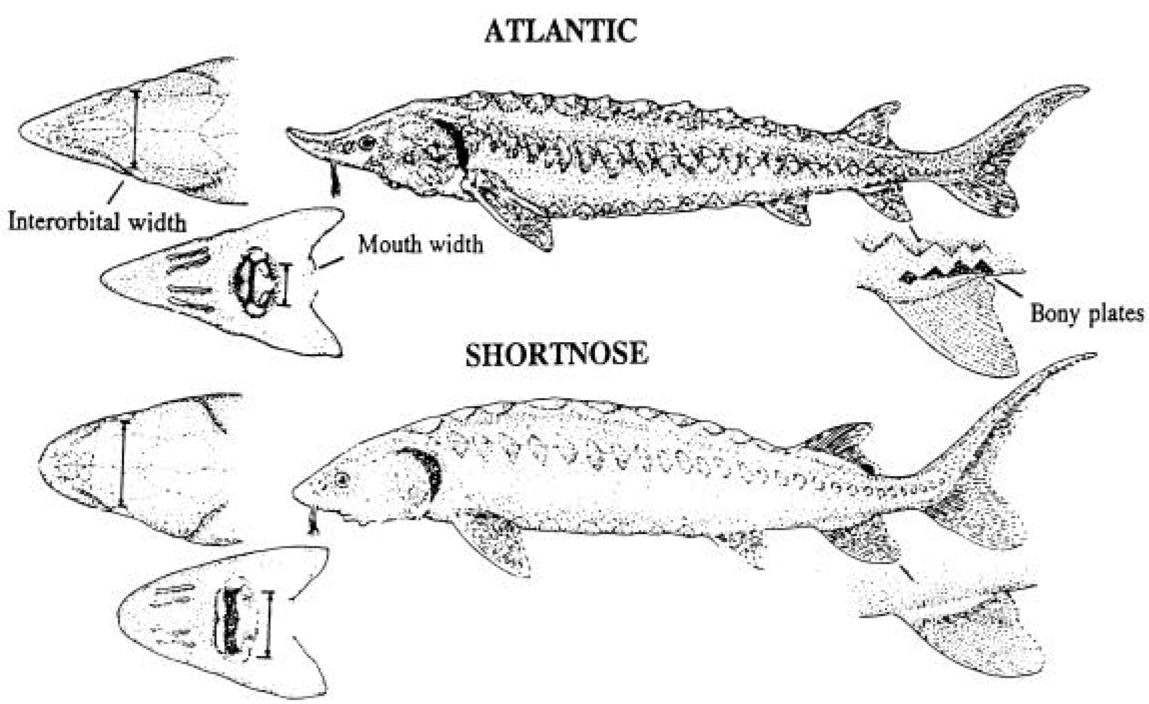
Recently hatched shortnose and Atlantic sturgeon larvae can be differentiated tentatively by size relative to state of development and, depending on the river, by collection date and location. Following yolk depletion, ventral pigmentation and distance between lobes of the lower lips are the most obvious diagnostic characteristics between the two species. The ventrolateral and ventral surfaces of the abdomen are white on shortnose sturgeon but covered with melanophores on Atlantic sturgeon, except on the midventral surface of smaller specimens. The distance between the two lobes of the lower lip is greater than 25% of the mouth width (including lips) for shortnose sturgeon and less than 20% for Atlantic sturgeon. For specimens over 60 mm SL, shortnose sturgeon have 17-22 pelvic and 18-24 anal fin rays while Atlantic sturgeon possess 26-33 pelvic and 22-30 anal fin rays (Snyder 1988).

Shortnose sturgeon are generally larger than Atlantic sturgeon in total length at hatching; about 9-10 mm standard length (SL) versus 7-9 mm SL, respectively. Shortnose sturgeon generally continue to be slightly larger than Atlantic sturgeon at the same developmental stage, at least through 60 mm SL (Snyder 1988). However, Atlantic sturgeon grow more quickly than shortnose sturgeon found in the same geographic region. For example, based on the growth curve for the Altamaha River shortnose sturgeon population (Dadswell et al. 1984), a 2-year old fish should be approximately 51 cm fork length (FL) while an Atlantic sturgeon of the same age from the Altamaha River would be approximately 67 cm FL (Rogers and Weber 1994); a 10-year old shortnose sturgeon would be approximately 83 cm fork length (FL) and a female Atlantic sturgeon would be approximately 175 cm FL. The maximum length for shortnose sturgeon in the Altamaha River is 97 cm FL (von Bertalanffy growth curve in Dadswell et al. 1984) while Rogers and Weber (1994) report female Atlantic sturgeon in excess of 250 cm FL.

Table 2. Distinguishing Characteristics of Atlantic and Shortnose Sturgeon

Characteristic	Atlantic Sturgeon *Acipenser oxyrinchus*	Shortnose Sturgeon *Acipenser brevirostrum*
Maximum length	> 9 feet	4 feet
Snout	Longer and more sharply pointed*	Shorter and blunter
Mouth	Width inside lips < 55% of bony interorbital width	Width inside lips > 62% of bony interorbital width
Bony plates	2-6 bony plates (at least pupil size) along base of anal fin	No row of bony plates along the base of anal fin
Habitat/Range	Anadromous; spawn in freshwater but primarily lead a marine existence	Anadromous; spawn at or above head-of-tide in most rivers. Aside from seasonal migrations to estuarine waters, rarely occurs in the marine environment

*Snout length and sharpness is less pronounced in older individuals



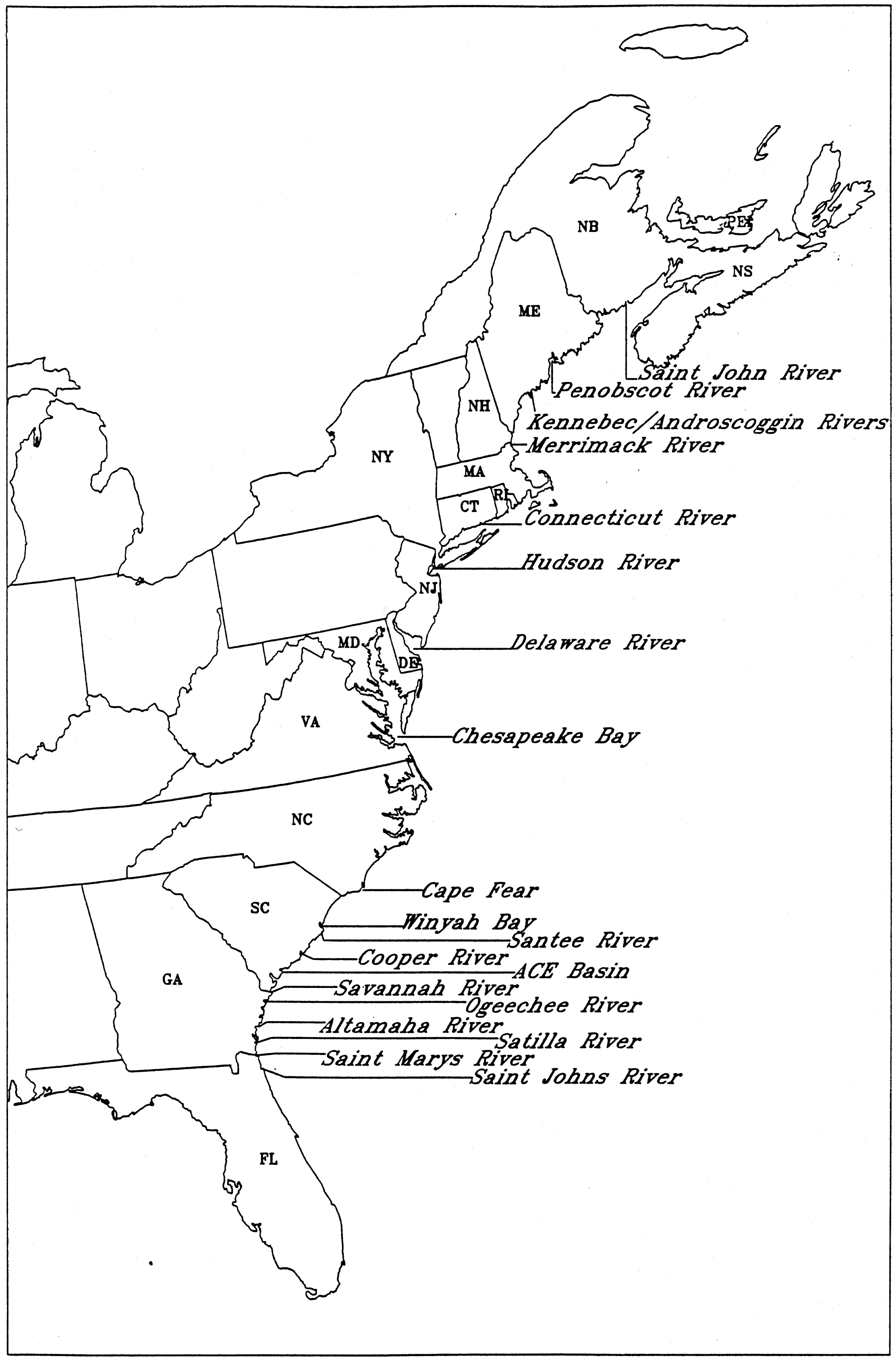
In northern rivers shortnose sturgeon attain maximum lengths of as much as 130 cm FL (Saint John River, New Brunswick), but are still well short of maximum lengths attained by Atlantic sturgeon (Dadswell 1979).

POPULATION STATUS

Population Size and Distribution

Shortnose sturgeon occur in estuaries and rivers along the east coast of North America (Vladykov and Greeley 1963) (Figure 1). Their northerly distribution extends to the Saint John River, New Brunswick, Canada, which has the only known population in Canada (Scott and Scott 1988). Their southerly distribution historically extended to the Indian River, Florida (Everman and Bean 1898). Shortnose sturgeon appear to spend most of their life in their natal river systems, only occasionally entering the marine environment. Those fish captured in the ocean are usually taken close to shore, but in full salinity (Schaefer 1967; Holland and Yelverton 1973; Wilk and Silverman 1976). There are no records of shortnose sturgeon in the NMFS' database for the northeast offshore bottom trawl survey.

Occurrences of shortnose sturgeon over the range of the species were chronicled by Dadswell et al. (1984). This chronology will not be repeated here, but rather a summary of the most current data on the presence of the species in river-estuary ecosystems, and the size and status of shortnose sturgeon populations is provided. The summary is organized by river-estuary system or groups of systems. Some small coastal streams are omitted from the summary due to a lack of data or a general suspicion that they contain insufficient habitat to support shortnose sturgeon. This should not be construed as proof that shortnose sturgeon do not occur or never occurred in these systems.



NB
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Saint John River
Penobscot River
Kennebec/Androscoggin Rivers
Merrimack River
Connecticut River
Hudson River
Delaware River
Chesapeake Bay
Cape Fear
Winyah Bay
Santee River
Cooper River
ACE Basin
Savannah River
Ogeechee River
Altamaha River
Satilla River
Saint Marys River
Saint Johns River

Figure 1. Shortnose Sturgeon Distribution

Table 3. Shortnose Sturgeon Population Estimates*

Locality	**Time**	**Type**	**Marked (m)**	**Captured (c)**	**Re-captured**	**Estimate Type**	**Population estimate**	**Precision 95% CI**		**Source**
Saint John	1973-77	Adult	3,705	4,082	343	S-J	18,000	± 30%		Dadswell 1979
Kennebec	1977-81	Adult	703	272	56	SCH	7,222	5,046	10,765	Squiers et al. 1982
Merrimack	1989	Spawning males				CAP	5	5	20	Kynard unpublished data
	1988-90	Spawning males				CAP	12	10	28	Kynard unpublished data
	1989-90	Total				CAP	33	18	89	Kynard unpublished data
Upper Connecticut	1992	Spawning				CAP	47	33	80	Kynard unpublished data
	1993	Spawning				CAP	98	58	231	Kynard unpublished data
	1976-77	Total	51	162	16	PET	516	317	898	Taubert 1980
	1976-78	Total	51	56	4	PET	714	280	2,856	Taubert 1980
	1977-78	Total	119	56	18	PET	370	235	623	Taubert 1980
	1976-78	Total	170	56	24	PET	297	267	618	Taubert 1980
Lower Connecticut	1988-93	Adult				SHU	895	799	1,018	Savoy and Shake 1993
	1988-93	Adult				SCH	875			
	1988-93	Adult				CHA	856			
Hudson	1979	Spawning	548	899	38	PET	12,669			Dovel 1979
	1980	Spawning	811	698	40	PET	13,844			Dovel 1979
	1980	Total					30,311			Dovel 1979 (extrapolation)
	1995	Adult	1909	2201	29	CAP	38,024	26,427	55,072	Bain et al. 1995
Delaware	1981-84	Partial				PET	14,080	10,079	20,378	Hastings et al. 1987
	1981-84	Partial				SCH	12,796	10,288	16,267	Hastings et al. 1987
	1983	Partial				S-J	6,408			Hastings et al. 1987
Ogeechee	1993	Total	31	36	5	SCH	361	326	400	Rogers and Weber 1994
Altamaha	1988	Total	64	87	1	SCH	2,862	1,069	4,226	
	1990	Total	112	175	24	SCH	798	645	1,045	

	1993	Total	44	83	7	SCH	468	316 903	Rogers unpublished data

Estimate Types: S-J=Seber Jolly, PET=Modified Petersen, SCH=Modified Schnabel, CAP=CAPTURE Method, SHU=Schumacher, CHA=Chapman, SPET=Simple Petersen

* Population estimates should be viewed with caution. In some cases, sampling biases may have violated the assumptions of the procedures used or resulted in inadequate representation of a population segment. Population estimates are not available for the following river systems: Penobscot, Chesapeake Bay, Cape Fear, Winyah Bay, Santee, Cooper, ACE Basin, Savannah, Satilla, St. Marys and St. Johns.

In addition to the wild populations of shortnose sturgeon described below, a captive broodstock from the Savannah River and its cultured progeny are housed at three hatcheries operated by the FWS: Bear's Bluff (South Carolina), Orangeburg (South Carolina), and Warm Springs (Georgia). The University of Florida (Gainesville) recently acquired shortnose sturgeon from these hatcheries for research purposes.

Northeast Region

Saint John River

The Saint John River in New Brunswick, Canada, supports one the largest populations of shortnose sturgeon in North America. Dadswell (1979) conducted a tag-and-recapture study on this population from 1973 to 1977. Due to the size of the study area and the inability to satisfy the assumption of random mixing required for other estimation procedures, Dadswell (1979) used a Seber-Jolly multiple mark-recapture model to generate a population estimate of 18,000 adult sturgeon (Table 3). A 1992 survey indicated that catch-per-unit-effort was unchanged from the previous estimate: approximately 15 sturgeon per net/night.

Eastern Maine Rivers: Dennys, Machias, East Machias, Penobscot, Ducktrap

A shortnose sturgeon was captured in the Penobscot River estuary (Northport, Maine) on June 30, 1978, during a Maine Department of Marine Resources sampling program (Squiers and Smith 1979). This capture indicates that a contemporary shortnose sturgeon population exists in the Penobscot River, as this capture occurred within the generation time of the species. Additionally, archeological data suggesting that sturgeon from the Penobscot River were used by native peoples (Knight 1985; Petersen and Sanger 1986) provides support for the conclusion that shortnose sturgeon occur in this system. Atlantic and shortnose sturgeon co-occur throughout the shortnose sturgeon:s range. Thus, evidence confirming even Atlantic sturgeon presence in the Penobscot River strongly suggests that shortnose sturgeon also occurred there.
A directed survey for shortnose sturgeon was conducted during 1994 and 1995 in the Penobscot River at the head of tide. No shortnose sturgeon were captured in 409 net hours of gill net effort;

however, this is much less effort than the 11,396 net hours expended by Kieffer and Kynard (1993) to capture 25 shortnose sturgeon in the Merrimack River and far less than the 21,432 net hours of gill net effort expended by Moser and Ross (1995) to capture three shortnose sturgeon in the Cape Fear River. Discharge rates and river depths associated with some of the small coastal rivers between the Kennebec and Saint John rivers may not be sufficient to support shortnose sturgeon populations in this region.

Sheepscot-Kennebec-Androscoggin Rivers

Shortnose sturgeon occur in the estuarine complex formed by the Sheepscot, Kennebec, and Androscoggin rivers. Sturgeon were tagged with Carlin tags from 1977 to 1980, with recoveries in each of the following years. A Schnabel estimate of 7,222 adults was computed and is considered the most reliable estimate of population size for the combined estuarine complex (Table 3). Tracking studies to delineate spawning habitat were performed on the Androscoggin River during 1993. Gill nets were used to capture study animals and catch rates were recorded. Gill net catch-per-unit-effort during this study was the highest recorded in this area, suggesting that the population in the Androscoggin has increased since last surveyed.

On September 19, 1994, the NMFS received a petition from the Edwards Manufacturing Company, Inc., to delist shortnose sturgeon occurring in the Androscoggin and Kennebec rivers. In the ensuing status review, the NMFS found that the petition to delist this population segment was not warranted because: 1) the population estimate used by the petitioners was less reliable than the best estimate accepted by the NMFS; 2) the best population estimate available did not exceed the interim threshold at which the population segment would be a candidate for delisting; 3) no recent information was available to assess population dynamics; and 4) threats to shortnose sturgeon habitat still exist throughout the Androscoggin and Kennebec rivers (NMFS 1996). Recent population dynamics data and genetic information are needed for a further assessment of the status of this population segment.

Western Maine Rivers: Royal, Presumpscot, Saco, Kennebunk, York

There are no known shortnose sturgeon populations in the rivers between the Androscoggin and

Merrimack rivers. A 1989 shortnose sturgeon survey in Great Bay, New Hampshire, resulted in zero catch (Nelson 1989). However, the lower salinity reaches of the system may not have been adequately sampled.

Merrimack River

There is a small population of shortnose sturgeon present in the Merrimack River (Kieffer and Kynard 1993). The size of the population has been estimated by tag and release studies using PIT and external Carlin tags. Population estimates, calculated using CAPTURE methodology, of spawning males and all spawners were 5 and 12 sturgeon, respectively (Table 3). The foraging, or total adult population, is estimated to be 33 fish. These estimates are from recently initiated studies and may change over time.

Rhode Island and Eastern Connecticut Rivers: Taunton, Blackstone, Pawcatuck and Thames Rivers

There are no known shortnose sturgeon populations in the rivers between the Merrimack and Connecticut rivers. Shortnose sturgeon previously occurred in area coastal waters and in Narragansett Bay (Dadswell et al. 1984). No shortnose sturgeon were caught in the Taunton River during a gill net survey conducted in 1991 to 1992 (Burkett and Kynard 1993).

Connecticut River

The Holyoke Dam separates shortnose sturgeon in the Connecticut river into an upriver group (above Holyoke Dam) and a lower river group that occurs below the Holyoke Dam to Long Island Sound. The abundance of the upriver group has been estimated by mark-recapture techniques using Carlin tagging (Taubert 1980) and PIT tagging (Kynard unpublished data). The total upriver population estimates ranged from 297 to 714 adult sturgeon, and the size of the spawning population was estimated (using PIT tags) at 47 and 98 for the years 1992 and 1993, respectively (Table 3).

The shortnose sturgeon population estimate for the lower Connecticut is stratified by sturgeon total length. The population estimate for sturgeon >50 cm TL was based on a Carlin and PIT tag study from 1991 to 1993. Schumacher, Schnabel, and Chapman point estimates were all within 39 fish of each other and yielded a mean value of 875 adult sturgeon (Table 3). However, this number may overestimate the abundance of the lower river group because the sampled area is not closed to downstream migration of upriver fish (Kynard 1997).

Western Connecticut: Housatonic River

There are no known shortnose sturgeon populations in the rivers between the Connecticut and Hudson rivers.

Hudson River

The shortnose sturgeon population in the Hudson River was estimated by a mark-and-recapture experiment performed in 1979 and 1980 (Dovel 1979). The adult spawning population was estimated at 13,000 fish (Table 3); this appears to be a robust estimate considering the number of fish tagged and recaptured. Subsequent survey work on shortnose sturgeon indicates that the population may be significantly larger. Researchers at Cornell University and Consolidated Edison have independently detected catch-per-unit-effort increases with their respective gears. Consolidated Edison data show a 3 to 6 fold increase in shortnose sturgeon trawl catch-per-unit-effort for 1992 (M.Bain, Cornell University, personal communication). In a mark-recapture study that replicated Dovel's (1979) methods, Bain et al. (1995) estimated the adult shortnose sturgeon population size to be 38,024. Although an initial estimate, this number suggests a 2 to 4 fold increase in adult shortnose sturgeon abundance in the Hudson River over the past decade. The Bain et al. (1995) study shows that recruitment is occurring despite limited captures of juveniles in recent surveys aimed at collecting juveniles (Haley et al. 1996).

New Jersey Coastal Rivers

There are no known shortnose sturgeon populations in the rivers between the Hudson and Delaware rivers.

Delaware River

Hastings et al. (1987) used Floy T-anchor tags in a tag-and-recapture experiment to estimate the Delaware River shortnose sturgeon population size, in the Trenton to Florence reach, between 1981 to 1984. Population sizes by three estimation procedures ranged from 6,408 to 14,080 adult sturgeon (Table 3). These estimates are useful but, because recruitment and migration rates between the population segment studied and the total population in the river are unknown, model assumptions may have been violated. With the limited scope of the tagging experiment, it is difficult to assess the status of the Delaware River shortnose sturgeon population.

Chesapeake Bay Drainages

The first published account of shortnose sturgeon in the Chesapeake system was an 1876 record from the Potomac River reported in a general list of the fishes of Maryland (Uhler and Lugger 1876). Other historical records of shortnose sturgeon in the Chesapeake include: Potomac River (Smith and Bean 1899), the upper Bay near the mouth of the Susquahanna River in the early 1980's, and the lower Bay near the mouths of the James and Rappahannock rivers in the late 1970's (Dadswell et al. 1984). Recently, in 1996, eight shortnose sturgeon were captured in commercial gear in the upper Bay, between Kent Island and the Chesapeake and Delaware (C&D) canal, and one shortnose sturgeon was captured in a pound net at the mouth of Potomac Creek, off the Potomac River. In 1997, nine shortnose sturgeon were collected in upper Chesapeake Bay between Miller's Island and the mouth of the Susquehanna River. No data on population dynamics exist. Directed sampling for shortnose sturgeon in this area is needed to establish distribution and movement patterns.

Southeast Region

Albemarle Sound/Roanoke and Chowan Rivers

The only published record of a shortnose sturgeon in this area, confirmed by a museum specimen, was from Salmon Creek in the lower Chowan River, April, 1881 (USNM 64330, Vladykov and Greeley 1963). An unconfirmed record from Oregon Inlet (Holland and Yelverton 1973) was also reported in Gruchy and Parker (1980), Dadswell et al. (1984), and Gilbert (1989). No data on population dynamics exist.

Pamlico Sound/ Pamlico and Neuse Rivers

Yarrow (1877) reported that shortnose sturgeon were abundant in the North, New, and Neuse Rivers, but these records are doubtful due to their apparent basis in hearsay (Ross et al. 1988). Shortnose sturgeon were also reported from the Beaufort (Jordan 1886) and Neuse Rivers by Fowler (1945). Nearshore records of shortnose sturgeon in this area (Holland and Yelverton 1973) may be misidentifications (Ross et al. 1988). No data on population dynamics exist.

Cape Fear River

Since the first confirmed capture of shortnose sturgeon in the Cape Fear River (January 1987, Ross et al. 1988), an extensive sampling program has produced eight additional specimens (Moser and Ross 1993). All nine specimens captured were adults; no juveniles were collected. The river is dammed in the coastal plain, a short distance upstream of Wilmington, North Carolina. The river channel near the coast is channelized and heavy industries exist near the port. No information is available on the population dynamics of this population segment, which probably numbers less than 50 fish (Moser and Ross 1995).

Winyah Bay Drainages

Shortnose sturgeon were documented in the Winyah Bay system during the late 1970's and early 1980's (Dadswell et al. 1984). Fed by the Waccamaw, Pee Dee, and Black Rivers, this coastal plain watershed produced over 100 collections of juveniles and adults during the study period.

No data on population dynamics exist.

Santee River

Seven shortnose sturgeon were recorded from the Santee River drainage in 1978, and one fish was captured in a gillnet in 1992 (Collins and Smith 1997). In addition, 20 specimens were recovered from a fishkill in the Santee Dam tailrace that occurred during a low dissolved oxygen event below the dam. During the period from 1979 - 1991, shortnose sturgeon were also recorded from Lake Marion, and in the Congaree and Wateree rivers above the dam (Collins and Smith 1997). Some suspect that these fish represent an essentially landlocked population (T.I.J. Smith, South Carolina Department of Natural Resources, personal communication). No population dynamics are available for this population segment.

Cooper River

Shortnose sturgeon were documented in what is now the metro Charleston area during the late 1800's (Jordan and Evermann 1896). Shortnose sturgeon were collected in this heavily altered (dammed and urbanized) drainage in the 1980's during research on the American shad (*Alosa sapidissima*) fishery. Eleven sturgeon were also taken in gillnets at the Pinopolis Dam tailrace in February 1995 (Collins et al. 1996). A functionally landlocked segment may exist in Lake Moultrie (T.I.J. Smith, South Carolina Department of Natural Resources, personal communication), above the dam that blocks the system in the lower coastal plain. Population dynamics are unknown.

Ashepoo, Combahee and Edisto Rivers (The "ACE" Basin)

The Ashepoo, Combahee, and Edisto drainages form one of the most pristine coastal plain watersheds in the southeastern United States. Shortnose sturgeon were incidentally collected during American shad studies in the Ashepoo and Edisto Rivers in the 1970's and early 1980's (Collins and Smith 1997). Population dynamics are unknown.

Savannah River

The Savannah River is a heavily industrialized and channelized drainage that forms the South Carolina/Georgia border. The river is dammed, but not below the fall line. Shortnose sturgeon were first documented in the system in the mid-1970's (Dadswell et al. 1984). During 1984-1992, over 600 adults were collected by shad fishermen and researchers using gillnets and trammel nets (Collins and Smith 1993). The ratio of adults to juveniles in this study was very high, indicating that recruitment is low in this river (Smith et al. 1992). Adult population estimates were calculated using Jolly Seber (96-1075) and Schnabel (1676) techniques, but were deemed unreliable as not all basic assumptions were met (M. Collins, South Carolina Department of Natural Resources, personal communication). During 1984-1992, approximately 97,000 shortnose sturgeon (19% tagged) of various sizes were stocked in the Savannah River to evaluate the potential for shortnose sturgeon stock enhancement (Smith and Jenkins 1991). Subsequent investigation showed that stocked fish were at large for an average of 416 days and comprised 41% of all juvenile sturgeon collected (Smith et al. 1995).

Ogeechee River

The Ogeechee is primarily a coastal plain drainage with 5% of its watershed in the piedmont. The river is undammed, but water quality has changed (eutrophied) during the last 30 years (Weber 1996). Shortnose sturgeon were first documented in the system during the early 1970's (Dadswell et al. 1984). A survey of shortnose sturgeon occurrence, distribution, and abundance, including a 1994-1995 mark/recapture experiment, was conducted from 1993 to 1995 in the tidal portion of the drainage (Rogers and Weber 1994; Weber 1996). The size distribution of shortnose sturgeon sampled indicated that, as in the Cape Fear and Savannah rivers, the Ogeechee population is dominated by adults. Mark/recapture analysis indicated that abundance is low in the Ogeechee system; the highest point estimate yielded less than 400 individuals from all age classes in 1993 (Weber 1996). Size frequency, abundance, and catch rate data indicate that shortnose sturgeon may be experiencing higher juvenile mortality rates in the Ogeechee River system than in the Altamaha (below).

Altamaha River

The Altamaha River system drains the largest watershed east of the Mississippi River and comprises the confluence of the Ocmulgee and Oconee Rivers plus additional, smaller piedmont and coastal plain drainages. The system is moderately industrialized including two kraft process paper mills and a nuclear generating plant. The watershed landscape has been heavily altered by urbanization, suburban development, agriculture, and silviculture. The system is also dammed, but not below the fall line. Shortnose sturgeon were first documented in the Altamaha in the early 1970's (Dadswell et al. 1984), and, later, in a cursory study of spawning movements conducted in the late 1970's (Heidt and Gilbert 1979).

A two-year study of population structure and dynamics was conducted during the early 1990's (Flournoy et al. 1992), building on three additional years of survey data from the late 1980's (B. T-A. Woodward, Georgia Department of Natural Resources, unpublished data). Over 650 individuals were collected during the five years of study, with samples heavily dominated by juveniles (90%). Subsequent analysis of tag/recapture data indicated that, during the two-year study period in the 1990's, abundance did not exceed 6,055 individuals for all size and age classes. However, under the more rigorous constraints imposed by the assumptions of the recapture model and (probably) met under the conditions experienced during the summer of 1990, the point estimate is 798 individuals with a 95% confidence interval (CI) of 645-1,045 fish. The next time that those conditions were met (during the late summer of 1993), a similar 95% CI of 316-903 individuals was generated with a point estimate of 468 fish. An estimate generated from 1988 data, which met the same criteria, yielded 2,862 fish (95% CI 1,069-4,226). Based on these data, the Altamaha population segment is likely the largest and most viable one south of Cape Hatteras, North Carolina.

Satilla and St. Marys

The Satilla and St. Marys Rivers are relatively small coastal plain drainages emptying into the Atlantic Ocean between the Altamaha River, Georgia and St. Johns River, Florida. There are no dams and few human impacts beyond agriculture and timber management along the Satilla system. The St. Marys system (draining the eastern portion of the Okefenokee Swamp and forming a portion of the Georgia/Florida border) is likewise undammed, but is heavily channelized in its estuary to support a small port and a major military installation. The estuary also receives effluents from three major forest product plants. Collections of shortnose sturgeon were made in the estuaries of both systems during the late 1980's and early 1990's during crustacean monitoring (G. Rogers, Georgia Department of Natural Resources, personal communication). Surveys for sturgeon in the St. Marys (1994 and 1995, 117 net hours) and in the Satilla (1995, 74 net hours) failed to yield any shortnose sturgeon (Rogers and Weber 1995b).

St. Johns River

The St. Johns River in Florida is a heavily altered system flowing northward from the east-central portion of the state and emptying into the Atlantic Ocean near Jacksonville, Florida. The system is dammed in the headwaters, heavily industrialized and channelized near the sea, and affected by urbanization, suburban development, agriculture, and silviculture throughout the basin. Shortnose sturgeon are known from the system since 1949 (Kilby et al. 1959). Five shortnose sturgeon were collected in the St. Johns in the late 1970's (Dadswell et al. 1984) and, in 1981, three sturgeon were collected and released by the Florida Game and Freshwater Fish Commission. Interestingly, none of the collections were recorded from the estuarine portion of the system; all captures occurred far upstream in an area heavily influenced by artesian springs with high mineral content.

BIOLOGICAL CHARACTERISTICS

Habitat and Life History

Shortnose sturgeon are found in rivers, estuaries, and the sea, but populations are confined mostly to natal rivers and estuaries. The species appears to be estuarine anadromous in the southern part of its range, but in some northern rivers it is "freshwater amphidromous", i.e., adults spawn in freshwater but regularly enter saltwater habitats during their life (Kieffer and Kynard 1993). Adults in southern rivers forage at the interface of fresh tidal water and saline estuaries and enter the upper reaches of rivers to spawn in early spring (Savannah River: Hall et al. 1991; Altamaha River: Heidt and Gilbert 1979; Flouronoy et al. 1992, Rogers and Weber 1995a; Ogeechee River: Weber 1996).

The use of saline habitat varies greatly among northern populations. In the Saint John and Hudson rivers, adults occur in both freshwater and upper tidal saline areas all year (Dadswell 1979; Dovel et al. 1992). This situation may also exist in the Kennebec River system where, during summer, some adults forage in the saline estuary while others forage in freshwater reaches (Squiers and Smith 1979; Squiers et al. 1981). In the Delaware, Merrimack, and Connecticut rivers adults remain in freshwater all year, but some adults briefly enter low salinity river reaches in May-June, then return upriver (Buckley and Kynard 1985a; Savoy and Shake 1992; Kieffer and Kynard 1993; O'Herron et al. 1993). Some adults have been captured in nearshore marine habitat (Dadswell et al. 1984), but this is not well documented. Many tagging and telemetry studies in rivers throughout the species' range indicate that these fish remain in their natal river or the river's estuary (Dadswell 1979; Dovel 1981; Dadswell et al. 1984; Buckley and Kynard 1985a; Hall et al. 1991; O'Herron et al. 1993; Savoy and Shake 1992; Kieffer and Kynard 1993; Moser and Ross 1995).

Early Life Stages

At hatching, shortnose sturgeon are blackish-colored, 7-11 mm long, and resemble tadpoles (Buckley and Kynard 1981; Dadswell et al. 1984). Hatchlings have a large yolk-sac, poorly developed eyes, mouth and fins, and are capable of only "swim-up and drift" swimming behavior (Richmond and Kynard 1995). They are ill-equipped to survive as free-swimming fish in the open river. In the laboratory, 1 to 8-day old shortnose sturgeon were photonegative, actively sought cover under any available material, and swam along the bottom until cover was found (Richmond and Kynard 1995). This cover-seeking behavior suggests that sturgeon yolk-sac larvae hide under any available cover at the spawning site. This tendency should enhance survival during final development (Richmond and Kynard 1995).

In 9-12 days shortnose sturgeon absorb the yolk-sac and develop into larvae at about 15 mm TL (Buckley and Kynard 1981). Larvae have well-developed eyes, a mouth with teeth, and fins capable of normal swimming. In the lab, larvae resemble miniature adults by 20 mm TL, begin exogenous feeding, are photopositive, and swim in the water column. In the wild, larvae of this size probably migrate downstream (Richmond and Kynard 1995). In laboratory experiments, larvae were nocturnal, and preferred deep water, grey color, and a silt substrate (Richmond and Kynard 1995). Larvae collected in rivers were found in the deepest water, usually within the channel (Taubert and Dadswell 1980; Bath et al. 1981; Kieffer and Kynard 1993). Laboratory studies indicate that young sturgeon move downstream in a 2-step migration: a 2-day migration by larvae followed by a residency period of YOY, then a resumption of migration by yearlings in the second summer of life. Thus, yearlings are the primary migratory stage (Kynard 1997).

In the Hudson and Saint John rivers YOY are found in freshwater (Dadswell 1979; Dovel et al. 1992). Carlson and Simpson (1987) examined stomach contents of YOY in the Hudson River and concluded that they consumed organisms found in the channel (amphipods), and dipteran larvae in the drift and mud substrate, but not sand. Pottle and Dadswell (1979) reported that, in the Saint John River, YOY use intermediate and deep water habitats. In the Connecticut River, upstream of Holyoke Dam where resident adults spawn, young juveniles have been captured in river reaches used by adults (Dadswell et al. 1984).

Juveniles

Juveniles (3-10 year olds) occur in at the saltwater/freshwater interface in most rivers (Saint John River: Dadswell 1979; Pottle and Dadswell 1979; Hudson River: Dovel et al. 1992; Savannah River: Hall et al. 1991; and Altamaha River: Flournoy et al. 1992, Ogeechee River: Weber 1996). Juveniles move back and forth in the low salinity portion of the salt wedge during summer (Pottle and Dadswell 1979). In the Ogeechee River, fish moved into more saline areas (0 - 16 ppt) and were most active when water temperature dropped below 16^{o}C (Weber 1996). Juveniles in the Savannah River use sand/mud substrate in 10-14 m depths (Hall et al. 1991); Saint John River juveniles use similar substrate in channels 10-20 m deep (Pottle and Dadswell 1979); and Hudson River juveniles have been collected over silt substrates in similar depths (Dovel et al. 1992; Haley et al. 1996). Warm summer temperatures (above 28^{o}C) may severely limit available juvenile rearing habitat in some southern rivers. In summer, juvenile habitat in the Altamaha River was limited mainly to one cool, deep water refuge (Flournoy et al. 1992). A similar distribution was observed in the Ogeechee River (Rogers and Weber 1994; Rogers and Weber 1995b; Weber 1996).

In the Connecticut River, where some juveniles and adults are always in freshwater, there was no macrohabitat segregation by age, i.e., both adults and juveniles used the same river reaches (Savoy 1991; Seibel 1993). Radio-tagged adults and yearlings in the Connecticut River show great individuality in choosing microhabitats, but macrohabitat types selected by adults and yearlings are similar (Seibel 1993).

Adults

Adult sturgeon occurring in freshwater or freshwater/tidal reaches of rivers in summer and winter often occupy only a few short reaches of the total river length (Connecticut River: Buckley and Kynard 1985a; Savoy and Shake 1992; Savannah River: Hall et al. 1991; Altamaha River: Flouronoy et al. 1992; Delaware River: O'Herron et al. 1993; and Merrimack River: Kieffer and

Kynard 1993). In the Connecticut and Merrimack Rivers, the "concentration areas" used by fish were reaches where natural or artificial features cause a decrease in river flow, possibly creating suitable substrate conditions for freshwater mussels (Kieffer and Kynard 1993), a major prey item for adult sturgeon (Dadswell et al. 1984). Summer concentration areas in southern rivers are cool, deep, thermal refugia, where adults and juveniles congregate (Flouronoy et al. 1992; Rogers and Weber 1994; Rogers and Weber 1995b; Weber 1996).

Riverine summer foraging and overwintering have been studied in detail in northern rivers. In the Connecticut River, adult and juvenile summer home ranges are about 10 km. Winter range is usually less than 2 km, with fish overwintering in deep areas, usually within or near the summer range (Seibel 1993). Fish foraging activity is almost equal during day and night. In the summer, foraging adults in the Connecticut River prefer curved or island reaches, not straight runs. Connecticut River sturgeon appear to prefer gravel and rubble substrate in summer, but sand in winter. Most adult sturgeon occur in slightly deeper water during the day than at night. In daytime, sturgeon seek regions with bottom water velocities of 0.25-0.5 cm/s, and illumination levels < 2,555 lx. Seibel (1993) found some shortnose sturgeon to spend all day in the channel and moveto shoal areas at night, while others bahaved oppositely. Both channel and shoal areas are used for foraging in the Saint John and Delaware rivers (Dadswell 1979; O'Herron et al. 1993). In the Connecticut River, relative use of these two habitats by individuals differs (Seibel 1993).

Adult shortnose sturgeon in the Saint John estuary foraged on sand/mud or mud substrate with emergent macrophyte vegetation in 5-10 m depths in summer and overwintered in deep water with mud substrate. Adults captured in freshwater foraged in backwaters of estuarine lakes with aquatic vegetation or on mud substrate along river banks (Dadswell 1979). Kennebec and Androscoggin River adults foraged during the summer in Montsweag Bay, in tidal mud-flats with 18-25 ppt salinity, while tolerating rapid salinity changes (~ 10 ppt salinity/ 2 hours) (McCleave et al. 1977). Other adult sturgeon in the estuary system used shallow and deep tidal channels (salinity of 0- 21 ppt), some of which were surrounded by aquatic vegetation (Squiers and Smith

1979; Squiers et al. 1981).

Reproduction

Length and age at maturity

Length at maturity (45 - 55 cm FL) is similar throughout the shortnose sturgeon's range, but because fish in southern rivers grow faster than those in northern rivers, southern fish mature at younger ages (Dadswell et al. 1984). Males spawn first at 2-3 years in Georgia, 3-5 years in South Carolina, and 10-11 years in the Saint John River, Canada. Females first spawn at 6 years or less in the Savannah River, 7-10 years in the Hudson River, and 12-18 years in the Saint John River (Dadswell et al. 1984). Most shortnose sturgeon probably survive spawning, although there is some post-spawning mortality (B. Kynard, United States Geological Survey, personal observation).

Spawning Periodicity

Spawning periodicity is poorly understood, but males seem to spawn more frequently than females. Dadswell (1979) estimated that Saint John River males spawned at 2-year intervals; females at 3-5 year intervals. Some males in the Hudson River may spawn in successive years (Dovel et al. 1992). Sonic-tagged males spawned during three successive years in the Merrimack River (Kieffer and Kynard 1993). At least some males and females in the Savannah River may spawn in consecutive years but most apparently do not (Collins and Smith 1993).

Spawning behavior

The shortnose sturgeon spawning period is estimated to last from a few days to several weeks. In the Connecticut River, Buckley and Kynard (1985b) found that spawning lasted 2-5 days in 1980-1982, and Kynard (1997) noted that spawning lasted 7-13 days in 1989-1993. Spawning in the Delaware River lasted 5-17 days (O'Herron et al. 1993). Sturgeon in the Savannah River remained on the spawning grounds for 2-3 weeks (Hall et al. 1991). Altamaha River fish remained on suspected spawning grounds for as long as nine weeks (Rogers and Weber 1995a).

Groups of sturgeon in the Connecticut and Merrimack Rivers that were suspected to be spawning consisted of one female and 3-5 males (Buckley and Kynard 1985b; Kieffer and Kynard unpublished data). Males fertilize the female=s eggs as the eggs are released close to the substrate. In captivity, males nuzzle the anal and head areas of females, suggesting that females attract males with a chemical attractant (B. Kynard, personal observation).

Spawning Habitat

Information on the location and type of river reach used for spawning is available for many rivers. Microhabitat data is available for spawning sites in the Connecticut and Merrimack Rivers. In populations that have free access to the total length of a river, (e.g., no dam within the species' range in the river), spawning areas are located at the most upstream reach of the river used by sturgeon (Saint John, Kennebec, and Altamaha rivers: Dadswell et al. 1984, Rogers and Weber 1995a; Savannah River: Hall et al. 1991; Delaware River: O'Herron et al. 1993; Merrimack River: Kieffer and Kynard 1993).

Channels are important for spawning in many rivers. Characteristic channel spawning habitats vary slightly among rivers: gravel substrate in the Saint John River (Dadswell 1979); gravel, rubble, and ledge bottom in moderate flow (0.8 m/sec) in the Androscoggin River (Squiers et al. 1993); rubble/boulder substrate in the Merrimack and Connecticut rivers (Kynard 1997); riffles in the Delaware River (O'Herron et al. 1993); in curves with gravel/sand/log substrate in the Savannah River (Hall et al. 1991); and areas near limestone bluffs with gravel to boulder substrate in the Altamaha River (Rogers and Weber 1995a). In the Merrimack River, telemetry studies revealed that spawning males occurred in water 2.3-5.8 m deep and in bottom water velocities ranging from 0.2-0.7 m/sec (mean = 0.4 m/sec; Kieffer and Kynard 1996). In the Connecticut River, radio-tagged females used spawning depths of 1.2-10.4 m deep and bottom water velocities of 0.4-1.8 m/sec (mean = 0.7 m/sec; Buckley and Kynard 1985b; Kynard 1997).

Spawning timing and river conditions

Spawning begins in freshwater from late winter/early spring (southern rivers) to mid to late-spring (northern rivers) when water temperatures increase to 8-9^{o}C. Spawning usually ceases when water temperatures reach 12-15°C (Dadswell et al. 1984; Buckley and Kynard 1985b; Hall et al. 1991; O'Herron et al. 1993; Squiers et al. 1993; Kynard 1997). However, shortnose sturgeon may spawn at higher temperatures. For example, when high river flow conditions delayed spawning in the Connecticut River, shortnose sturgeon had the physiological flexibility to spawn successfully at 18°C (Kynard 1997).

Dadswell (1979) documented spawning from mid-May to mid-June, at the end of the spring freshet, in the Saint John River. Spawning in the Connecticut and Merrimack rivers occurs from the last week of April to mid-May; well after peak spring flows but in moderate, decreasing river discharge (Taubert 1980; Buckley and Kynard 1985b; Kynard 1997). The pattern in the Hudson River appears similar (Dovel et al. 1992). In general, spawning occurs earlier in the year in southern rivers and at moderate river discharge levels (relative to northern rivers). For example, spawning occurs in early-February to mid-March in the Savannah River (Hall et al. 1991)

Physical factors affecting spawning success

High river flows during the normal spawning period can cause unacceptably fast bottom water velocities and prevent females from spawning. This situation was observed in the Connecticut River in early May of 1983 and 1992 when flow was higher than normal and temperature was lower than normal, but still adequate for spawning. (Buckley and Kynard 1985b; Kynard 1997). Buckley and Kynard (1985b) speculated that the reproductive rhythm of females may be under endogenous control and suitable river conditions must be available or endogenous factors prevent females from spawning. Thus, reproductive success depends on suitable river conditions during the spawning season.

Growth

Growth of juvenile shortnose sturgeon is fast throughout the species' range (Dadswell et al. 1984). YOY are 14 - 30 cm TL after the first year. Fish reach 50 cm after only 2-4 years in the southern part of the range. In the Saint John River, juvenile growth is in two stages: slower growth during 1- 9 years and more rapid growth for 10 - 11 year olds **C** the age when stugeon begin to use more productive estuarine areas.

Dadswell et al. (1984) reviewed growth throughout the shortnose sturgeon's latitudinal range. Fish grow faster in the South, but do not attain the large sizes of northern fish. Adults upstream of the Holyoke Dam in the Connecticut River had the slowest growth rate of any group examined, perhaps because they are unable to use estuarine foraging areas.

Survival and Recruitment

There is no information on survival of eggs or early life stages in the wild. Many eggs reared in captivity die of fungus infections (Dadswell et al. 1984). Richmond and Kynard (1995) maintain that the availability of spawning substrate with crevices is critical to survival of eggs and embryos. Year class strength of shortnose sturgeon populations is probably established early in life, perhaps in the initial few weeks. Although there is no commercial fishery for shortnose sturgeon (and thus, no fisheries recruitment information), some fisheries incidentally catch adult sturgeon and poaching impacts all populations to an unknown degree. Savoy and Shake (1992) estimated 2 - 25 adults were taken annually by the Connecticut River fishery for American shad (*Alosa sapidissima*). At least this many sturgeon may be taken illegally each year by sport fishermen in the Connecticut River (B. Kynard personal observation). The length frequency curve for Connecticut River adults is normal, not truncated, so adult mortalities due to fishing may not be a major factor limiting numbers.

Incidental capture of shortnose sturgeon also occurs in gill net fisheries in the southern portion of the shortnose sturgeon's range. Gill net fisheries for American shad and trawl fisheries for shrimp (*Penaeus* spp.) in Georgia and South Carolina captured about 2% of a tagged sample of shortnose sturgeon (Collins et al. 1996). The gill net fishery was responsible for 83% of the total shortnose sturgeon captures. Moser and Ross (1993) reported that 4 of 7 telemetered adult sturgeon in the Cape Fear River were captured in the gill net fishery for American shad or striped bass (*Morone saxatalis*). In addition, recent apprehension of poachers operating in South Carolina indicates that illegal directed take of shortnose sturgeon in southern rivers may be a significant source of mortality (D. Cooke, personal communication).

Natural mortality

Estimates of total instantaneous mortality rates (Z) are available for several river systems. Dadswell (1979) estimated Z to be between 0.12 and 0.15 for shortnose sturgeon (ages 14 through 55) in the Saint John River, New Brunswick, Canada. The fishing mortality rate (F) for the Saint John River was estimated to be 0.012, which would result in a natural mortality rate (M) of 0.11 to 0.14. Taubert (1980) estimated Z to be 0.12 for adult shortnose sturgeon in the Holyoke Pool portion of the Connecticut River. It is likely that F is very low in this population, so the natural mortality rate is probably very close to Z. Total mortality for the Pee Dee-Winyah River in South Carolina was estimated at 0.08 to 0.12 (Dadswell et al. 1984). All of the above estimates were based on catch curves which were adjusted for gill net selectivity and effort. Using catch curves and Hoenig's technique, total instantaneous natural mortality (M) for shortnose sturgeon in the Connecticut River estuary was estimated to be 0.13 (T. Savoy, Connecticut Department of Environmental Protection, personal communication).

Annual egg production

Annual egg production is determined by the fecundity of females and the number of spawning females. Estimates of egg production from the Saint John River indicated that approximately one-third of the females matured annually (4,000) and mean fecundity per female was 94,000 eggs (Dadswell 1979). More detailed analysis indicates that this situation is more complicated. Monitoring of spawner abundance in the Connecticut River indicated that abundance varies greatly from year to year: in 1992 there were 47 spawners, while in 1993, 98 spawners were detected (Kieffer and Kynard unpublished data). Further, it appears that not every mature female spawns successfully. In the Connecticut River, one of four female shortnose sturgeon removed for egg culture in 1988 could not spawn due to a tumor (B. Kynard, personal observation). Smith et al. (1992) also suggested that spawner abundance in the Savannah River can fluctuate greatly from year to year. This information indicates that the number of eggs spawned annually varies greatly (possibly by several magnitudes) over the species' range and complicates estimation of annual egg production.

Fecundity and sex ratio

Gonadal maturity and fecundity of females were characterized by Dadswell (1979) for the Saint John River, Canada. Just prior to spawning, egg diameter was 3.1 mm and the ovaries composed 25 percent of the body weight. The number of eggs released ranged from 27,000 to 208,000 (11,568 eggs/kg body weight).

In the Connecticut River females are much less mobile and less subject to capture in nets than males, making estimation of sex ratios difficult (Buckley and Kynard 1985b; Kieffer and Kynard unpublished data). Males were most abundant in the available estimates for the Hudson River (2.5:1, Pekovitch 1979), Connecticut River (3.5:1, Taubert 1980; and 3 to 7:1, Buckley and Kynard 1985b), and Savannah River (3.5:1, Collins and Smith 1997).

Migration and Movements

Movement patterns in shortnose sturgeon vary with fish size and home river location (Figures 2 and 3). Juvenile shortnose sturgeon generally move upstream in spring and summer and move back downstream in fall and winter; however, these movements usually occur in the region above the saltwater/freshwater interface (Dadswell et al. 1984; Hall et al. 1991). Adult shortnose sturgeon exhibit freshwater amphidromy (i.e., adults spawn in freshwater but regularly enter saltwater habitats during their life) in some rivers in the northern part of their range but are generally estuarine anadromous in southern rivers (Kieffer and Kynard 1993). While this species is occasionally collected near the mouths of rivers, shortnose sturgeon are not known to participate in coastal migrations (Dadswell et al. 1984).

Spawning migrations are apparently triggered when water temperatures warm above 8^{o}C (Dadswell et al. 1984). Consequently, spring spawning migrations occur earlier in southern systems than in northern ones (Figures 2 and 3): January-March (Altamaha River: Gilbert and

Heidt 1979, Rogers and Weber 1995a; Savannah River: Hall et al. 1991; Pee-Dee/Waccamaw Rivers: Dadswell et al. 1984; Cape Fear River: Moser and Ross 1993), late March (Delaware River: O'Herron et al. 1993), and April-May (Hudson River: Dovel 1979; Holyoke Pool: Taubert 1980; Androscoggin/Kennebec Rivers: Squiers et al. 1982; Merrimack River: Kieffer and Kynard 1993). In the lower Connecticut and Saint John rivers, most of the ripening shortnose sturgeon migrate to their spawning grounds in August-October and remain near the spawning areas (i.e., overwinter) until spring (Dadswell 1979; Buckley and Kynard 1985a). Kieffer and Kynard (1993) hypothesized that these pre-spawning adults migrate in fall to avoid long upstream migrations during high discharge periods in spring. In the Altamaha River, Rogers and Weber (1995a) also documented upstream movement of most adults to suspected spawning grounds in autumn (late November - early December). A second spawning migration occurred in that system during mid-winter (late January - early February).

A shortnose sturgeon spawning migration is characterized by rapid, directed and often extensive upstream movement. Hall et al. (1991) tracked adults during pre-spawning upstream migrations of up to 200 km in the Savannah River and Dadswell et al. (1984) noted that migrations of 160 and 193 km occur in the Saint John and Altamaha rivers, respectively. Telemetry studies have documented maximum ground speeds of 20-33 km d^{-1}, although mean ground speeds during riverine spawning migrations were around 16 km d^{-1} (Buckley and Kynard 1985a; Hall et al. 1991; Moser and Ross 1993). Both Hall et al. (1991) and Moser and Ross (1993) observed that spawning migrations are easily interrupted by capture and handling or by dams. Non-spawning movements include rapid, directed post-spawning movements to downstream feeding areas in spring and localized, wandering movements in summer and winter (Dadswell et al. 1984; Buckley and Kynard 1985a; O'Herron et al. 1993). Shortnose sturgeon usually leave the spawning grounds soon after spawning. Kieffer and Kynard (1993) reported that post-spawning migrations were correlated with increasing spring water temperature and river discharge. Post-spawning migration rates range from 3.5-36 km d^{-1} (Buckley and Kynard 1985a; Hall et al. 1991; Kieffer and Kynard 1993). During these movements shortnose sturgeon apparently move singly and "home" to very specific sites (Dadswell et al. 1984; Kieffer and Kynard 1993; Savoy and Shake

1992).

Continuous tracking of shortnose sturgeon provides detailed information on their migratory behavior. Moser and Ross (1994) demonstrated that, in the Cape Fear River estuary, upstream spawning migration in saltwater was slower (10 km d^{-1}) than migration in freshwater (15 km d^{-1}). This was due to the saltatory nature of movement in the estuary and faster swimming (0.8 body lengths (BL) s^{-1}) in freshwater than in the estuary (0.6 BL s^{-1}). Estimated swimming speed during summer, 0.07-0.37 BL s^{-1}, is considerably slower than during spawning migrations (McCleave et al. 1977), while shortnose sturgeon are even less active in winter (Seibel 1993). Moser and Ross (1994) and McCleave et al. (1977) estimated swimming speed to be greatest when sturgeon oriented against rapid ebbing currents. Moser and Ross (1994) and McCleave et al. (1977) reported that shortnose sturgeon do not display any diel activity pattern, traveled in the upper part of the water column (within 2 m of the surface), and that their movement was apparently unaffected by temperature and salinity.

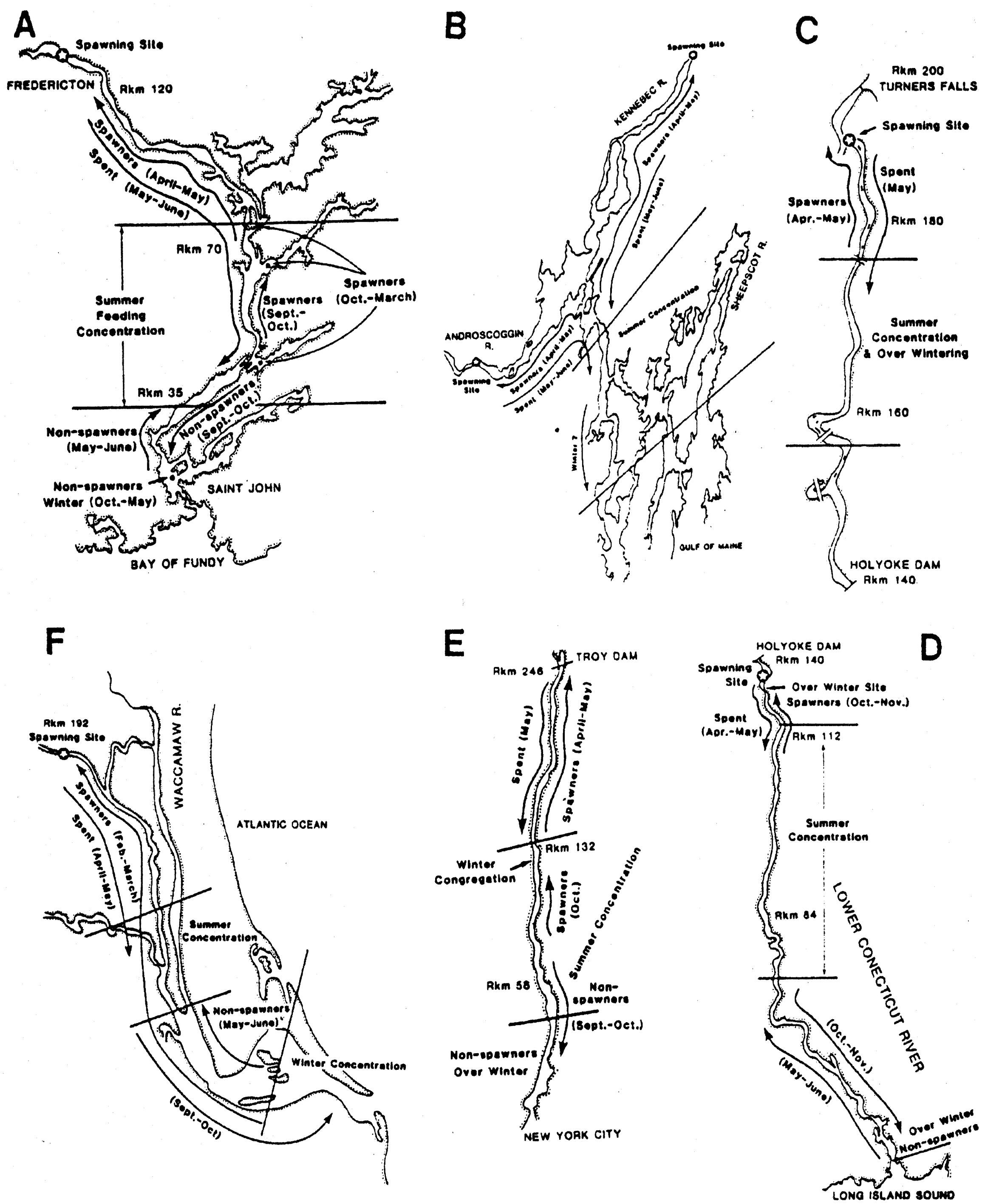

Figure 2. Migration patterns of shortnose sturgeon in the following rivers: A) Saint John (Canada), B) Kennebec, C) Holyoke Pool, Connecticut D) Lower Connecticut, E) Hudson, and F) Pee Dee. (from Dadswell et al. 1984).

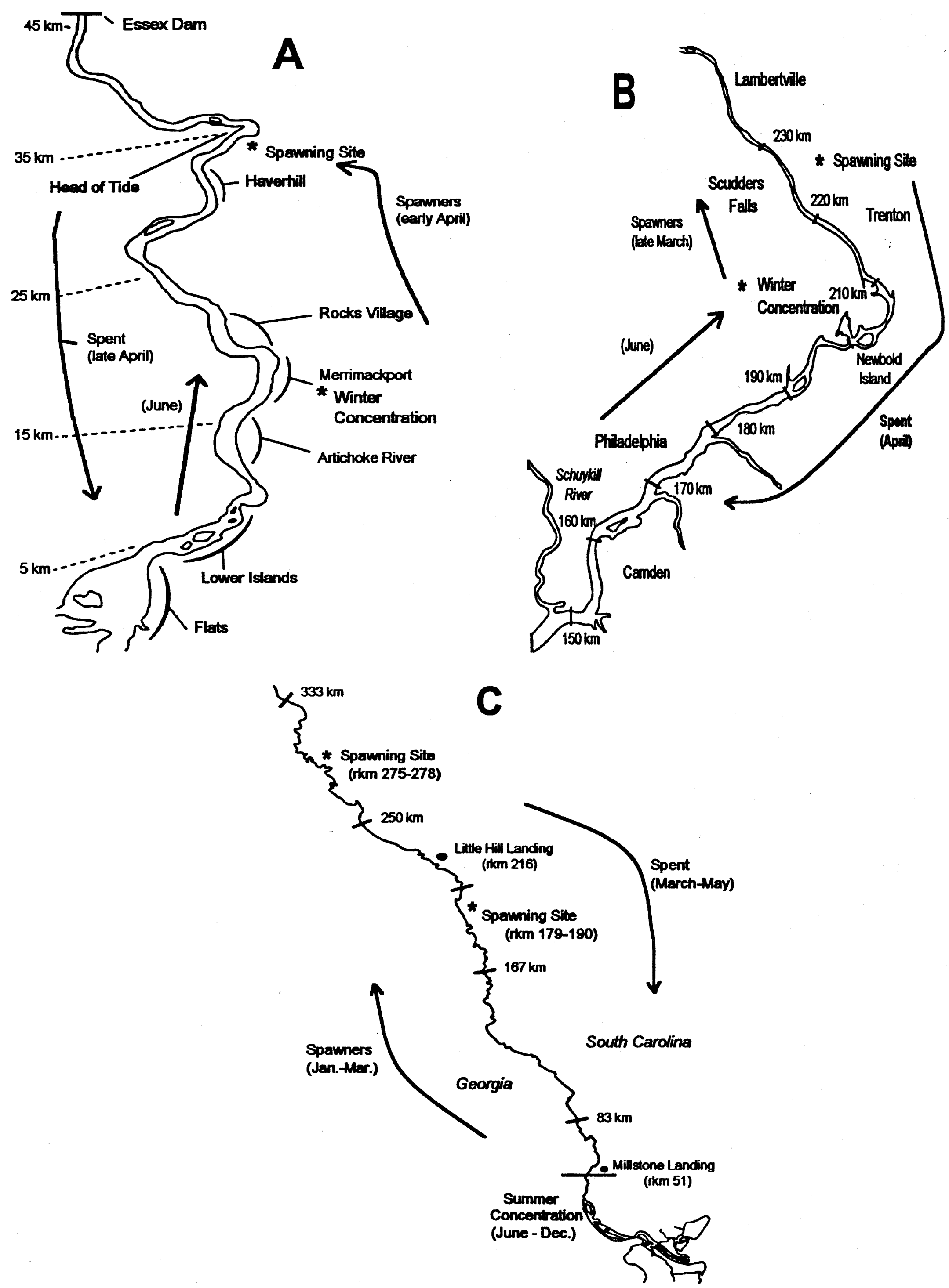
A
45 km
Essex Dam
35 km
Spawning Site
Head of Tide
Haverhill
Spawners
(early April)
25 km
Spent
(late April)
Rocks Village
Merrimackport
Winter
Concentration
(June)
15 km
Artichoke River
5 km
Lower Islands
Flats
B
Lambertville
230 km
Spawning Site
Scudders
Falls
220 km
Trenton
Spawners
(late March)
Winter
Concentration
210 km
(June)
Newbold
Island
190 km
180 km
Spent
(April)
Philadelphia
Schuylkill
River
170 km
160 km
Camden
150 km
C
333 km
Spawning Site
(rkm 275-278)
250 km
Little Hill Landing
(rkm 216)
Spent
(March-May)
Spawning Site
(rkm 179-190)
167 km
South Carolina
Spawners
(Jan.-Mar.)
Georgia
83 km
Millstone Landing
(rkm 51)
Summer
Concentration
(June - Dec.)

Figure 3. Recently documented migration patterns of shortnose sturgeon in the following rivers: A) Merrimack (Kieffer and Kynard 1993), B) Delaware (O'Herron et al. 1993), and C) Savannah (Hall et al. 1991).

Feeding

Shortnose sturgeon are benthic omnivores but have also been observed feeding off plant surfaces (Dadswell et al. 1984). Based on the high incidence of non-food items in juvenile shortnose sturgeon, Dadswell et al. (1984) concluded that juveniles randomly vacuum the bottom while adults are more selective feeders. Dadswell (1979) determined that adult shortnose sturgeon in the Saint John River are not opportunists and only switch to other prey when preferred foods are unavailable. The presence of food in the gut during all times of day indicated that shortnose sturgeon are continuous feeders (Dadswell 1979).

Shortnose sturgeon feed on crustaceans, insect larvae, worms, and molluscs; however, they apparently undergo ontogenetic shifts in preferred foods. Insect larvae (*Hexagenia* sp., *Chaoborus* sp., *Chironomus* sp.) and small crustaceans (*Gammarus* sp., *Asellus* sp., *Cyathura polita*) predominate in the diet of juveniles (Dadswell et al. 1984; Carlson and Simpson 1987) while adults feed primarily on small molluscs (Dadswell 1984; Hastings 1983). Molluscs ingested by adults captured in freshwater include *Physa* sp., *Heliosoma* sp., *Corbicula manilensis*, *Amnicola limnosa*, *Valvata* sp., *Pisidium* sp., and small *Elliptio complanata* (Dadswell et al. 1984). In saline areas molluscan prey include small *Mya arenaria*, and *Macoma balthica* (Dadswell 1979). A recent sturgeon food habits study in the Hudson River revealed that adult shortnose sturgeon prey include gammarid amphipods and zebra mussels (*Dreissena polymorpha*) (Haley, in press).

Shortnose sturgeon feeding patterns vary seasonally between northern and southern river systems. In the Connecticut River, foraging occurs in the summer in freshwater and saline reaches of the river (Buckley and Kynard 1985a; Savoy and Shake 1992). In the Saint John River estuary, summer foraging grounds consist of highly-vegetated, shallow freshwater regions while feeding occurs over sand-mud bottoms in the lower estuary during fall, winter and spring (Dadswell 1979). Females in this system fast during the eight months before spawning but ripening males continue to feed. In contrast, probable foraging activity in southern rivers have been described at the saltwater/freshwater interface during fall and winter in the Pee Dee and Savannah rivers (Dadswell et al. 1984; Hall et al. 1991) and just downstream of the saltwater/freshwater interface in the Altamaha and Ogeechee rivers (Rogers and Weber 1995a; Weber 1996). During summer, shortnose sturgeon in these southern systems appear to reduce activity, fast, and lose weight (Dadswell et al. 1984; Rogers et al. 1994).

Predators, Parasites, and Diseases

There is very little documentation of predation on any life stage of shortnose sturgeon. Young-of-the-year shortnose sturgeon (approximately 5 cm FL) were found in the stomachs of yellow perch (*Perca flavescens*) in the Androscoggin River, Maine (Dadswell et al. 1984). It is likely that sharks and seals may occasionally prey on shortnose sturgeon based on the occasional specimen lacking a tail (Dadswell et al. 1984).

A list of known parasites can be found in Table 4. The degree of infestation has been reported as being quite low with the exception of *Capillospirura* sp. (Dadswell et al. 1984). Sturgeon do not appear to be harmed by these parasites.

There have been no reported incidences of disease for shortnose sturgeon in the wild although an epizootic of *Columnaris* sp. occurred at the FWS: Orangeburg Hatchery in South Carolina (Willie Booker, FWS, South Carolina, personal communication).

Table 4. Parasites recorded from shortnose sturgeon

Group and species	Parasite location	Capture locality	Source
Coelenterata			
Polypodium sp.	Eggs	Saint John River[1]	Hoffman et al (1974)
Platyhelminthes	Gills	Saint John River	Appy and Dadswell (1978)
Diclybothrium armatum			
Spirochis sp.	Mesenteric blood vessels	Saint John River	Appy and Dadswell (1978)
Nitzschia sturionis	Gills	NY Aquarium (may be unnatural infection)	MacCallum (1921)
Nematoda			
Capillospirura pseudoargumentosus	Gizzard	Saint John River	Appy and Dadswell (1978)
Acanthocephala			
Fessesentis friedi	Spiral valve	Saint John River	Appy and Dadswell (1978)
Echinorhynchus attenuatus	?	Woods Hole	Sumner et al. (1911)
Hirudinea			
Calliobdella vivida	External	Connecticut River	Smith and Taubert (1980)
Piscicola milneri	External	Connecticut River	Smith and Taubert (1980)
Piscicola punctata	External	Connecticut River	Smith and Taubert (1980)

[1]Saint John River, N.B., Canada (Dadswell et al, 1984)

Arthropoda			
Argulus alosa	External	Saint John River	Appy and Dadwell (1978)
Pisces			
Petromyzon marinus	External	Saint John River	Dadswell (pers. obs.)

FACTORS AFFECTING RECOVERY

The FWS identified pollution and overharvesting in commercial fisheries as reasons for initially listing shortnose sturgeon as endangered under listing criteria set forth in the Endangered Species Conservation Act of 1969 (USDOI 1973). Many aspects of shortnose sturgeon biology and environmental tolerances are poorly understood, presumably because the sturgeon's endangered status limits access to study animals. As a result, there is much speculation about the factors that affect recovery of shortnose sturgeon populations yet not much conclusive evidence. However, as discussed below, we can identify various activities that, left unchecked, may contribute to the further decline and impede recovery of shortnose sturgeon. Several features of the species' natural history including delayed maturation, non-annual spawning (Dadswell et al. 1984; Boreman 1997), and long lifespan affect the rate at which recovery can proceed. Observable differences in population sizes, whether increases or decreases, will be difficult to quantify due to these characteristics.

Through Section 7 consultations, mandated by the Endangered Species Act, federal agencies are required to assess the impact(s) of federal projects on shortnose sturgeon. Projects that may adversely affect sturgeon include dredging, pollutant or thermal discharges, bridge construction/removal, dam construction, removal and relicensing, and power plant construction and operation. As a result of Section 7 consultations, the NMFS has obtained some valuable information regarding the extent to which these projects may affect shortnose sturgeon. In many cases, however, data are inconclusive in establishing any direct relationships between project activities and biological impacts to sturgeon populations. The following is a summary of the best available information regarding influences on sturgeon recovery throughout the species' range.

Commercial and Recreational Fishing

Directed harvest of shortnose sturgeon is prohibited by the ESA. However, shortnose sturgeon are taken incidentally in other anadromous fisheries along the east coast and are probably targeted by poachers throughout their range (Dadswell 1979; Dovel et al. 1992; Collins et al. 1996). Commercial and recreational shad fisheries operating in the Merrimack, Connecticut, Hudson, Delaware, Cape Fear, and various rivers in South Carolina and Georgia are known to incidentally capture shortnose sturgeon. Collins et al. (1996) reported that the shad gillnet fishery acccounted for 83% of shortnose sturgeon takes (n=10) in Georgia coastal fisheries. In northern rivers, state biologists estimate the number of lethal takes to approximate 20 fish per year (T. Savoy, CT Department of Environmental Protection, personal communication; A. Kahnle, New York State Department of Environmental Conservation, personal communication; T. Squiers, Maine Department of Marine Resources, personal communication). In the Saint John River estuary, shortnose sturgeon are taken incidentally in shad, salmon, striped bass, and alewife fisheries. In most cases fish are returned to the river, presumably unharmed. Moser and Ross (1993) found that captures of shortnose sturgeon in commercial shad nets disrupted spawning migrations in the Cape Fear River, and Weber (1996) reported that these incidental captures caused abandonment of spawning migrations in the Ogeechee River, Georgia.

Sturgeon may be most prone to capture during their spring spawning migration which coincides with the shad fishing season. In fall and winter, sturgeon congregate in deep depressions of river where there is little commercial fishing activity, although poaching probably occurs all year. While the impacts of poaching to individual population segments is unknown, this threat may be significant in some rivers. In 1995, two South Carolina fishermen were apprehended with five pounds of shortnose sturgeon roe and two live gravid fish (D. Cooke, S.C. Dept. of Natural Resources, Bonneau, S.C., personal communication). Poaching may be more prevalent where legal markets for sturgeon exist from importations, commercial harvest, or commercial culture.

Bridge Construction/Demolition

Bridge construction and demolition projects may interfere with normal shortnose sturgeon migratory movements and disturb sturgeon concentration areas. During construction of a new bridge upstream of sturgeon spawning habitat in the Connecticut River, concerns were raised that fine sediments emanating from the construction site might build up in the downstream spawning site and impair egg survival. In that instance, concerns were abated after it was demonstrated that fine sediments are cleanly dislodged from the spawning site during the high spring flood (N. Haley, NMFS, personal communication).

Bridge demolition projects may include plans for blasting piers with powerful explosives. Unless appropriate precautions are made to mitigate the potentially harmful effects of shock wave transmission to physostomous (i.e., air-bladder connected to the gut) fish like shortnose sturgeon, internal damage and/or death may result. There are no data available on the effects of blasting on sturgeon. In 1993-1994 the NMFS consulted with the Federal Highway Administration (FHWA) to assess the potential impacts to shortnose sturgeon of demolishing bridge piers in the lower Connecticut River with explosives. The NMFS advised the FHWA to employ several conservation measures designed to minimize the transmission of harmful shock waves. These measures included restricting the work to seasonal "work windows," installing double-walled cofferdams around each pier to be blasted, and dewatering the outer cofferdams. The use of an air gap (e.g., double-wall cofferdam, bubble screen) to attenuate shock waves is likely to reduce adverse effects to shortnose sturgeon and other swimbladder fish (Sonolysts 1994). Blast pressures below which negative impacts to shortnose sturgeon are unlikely to occur are not known. Wright (1982) determined that detonations producing instantaneous pressure changes greater than 100kPa (14.5 psi) in the swimbladder of a fish will cause serious injury or death.

Contaminants

Contaminants, including toxic metals, polychlorinated aromatic hydrocarbons (PAHs), pesticides, and polychlorinated biphenyls (PCBs) can have substantial deleterious effects on aquatic life including production of acute lesions, growth retardation, and reproductive impairment (Cooper 1989; Sindermann 1994). Ultimately, toxins introduced to the water column become associated with the benthos and can be particularly harmful to benthic organisms (Varanasi 1992) like sturgeon. Heavy metals and organochlorine compounds are known to accumulate in fat tissues of sturgeon, but their long term effects are not yet known (Ruelle and

Henry 1992; Ruelle and Keenlyne 1993). Available data suggest that early life stages of fish are more susceptible to environmental and pollutant stress than older life stages (Rosenthal and Alderdice 1976).

Although there have not been any studies to assess the impact of contaminants on shortnose sturgeon, elevated levels of environmental contaminants, including chlorinated hydrocarbons, in several other fish species are associated with reproductive impairment (Cameron et al. 1992; Longwell et al. 1992), reduced egg viability (Von Westernhagen et al. 1981; Hansen 1985; Mac and Edsall 1991), and reduced survival of larval fish (Berlin et al. 1981; Giesy et al. 1986). Some researchers have speculated that PCBs may reduce the shortnose sturgeon's resistance to fin rot (Dovel et al. 1992). Under a statewide toxics monitoring program, the New York State Department of Environmental Conservation analyzed tissues (i.e., fillet, liver, and gonad) from one shortnose sturgeon to determine PCB concentrations. In gonadal tissues, where lipid percentages are highest, the average PCB concentration was 29.55 ppm (Sloan 1981).

Several characteristics of shortnose sturgeon (i.e., long lifespan, extended residence in estuarine habitats, benthic predator) predispose the species to long-term and repeated exposure to environmental contamination and potential bioaccumulation of heavy metals and other toxicants (Dadswell 1979). In the Connecticut River, coal tar leachate was suspected of impairing sturgeon reproductive success. Kocan et al. (1993) conducted a laboratory study to investigate the survival of sturgeon eggs and larvae exposed to polyaromatic hydrocarbons (PAH's), a by-product of coal distillation. Approximately 5% of sturgeon embryos and larvae survived after 18 days of exposure to Connecticut River coal-tar contaminated sand in a flow-through laboratory system. This study demonstrated that coal-tar contaminated sediment is toxic to shortnose sturgeon embryos and larvae under laboratory exposure conditions (Kocan et al. 1993).

Although there is scant information available on levels of contaminants in shortnose sturgeon tissues, some research on other, related species indicates that concern about effects of contaminants on the health of sturgeon populations is warranted. Detectable levels of chlordane, DDE, DDT, and dieldrin, and elevated levels of PCBs, cadmium, mercury, and selenium were found in pallid sturgeon tissue from the Missouri River (U.S. Fish and Wildlife Service 1993). These compounds may affect physiological processes and impede a fish's ability to withstand stress. PCBs are believed to adversely affect reproduction in pallid sturgeon (Ruelle and Keenlyne 1993). Ruelle and Henry (1992) found a strong correlation between fish weight ($r = 0.91$, $p < 0.01$), fish fork length ($r = 0.91$, $p < 0.01$), and DDE concentration in pallid sturgeon livers, indicating that DDE concentration increases proportionally with fish size.

Point-source discharges (i.e., municipal wastewater, paper mill effluent, industrial or power plant cooling water or waste water) may also contribute to impacts stemming from poor water quality. Compounds associated with discharges, including metals, dioxin, dissolved solids, phenols, and hydrocarbons, can alter the pH of receiving waters, which may lead to mortality, alterations in fish behavior, deformations, and reduced egg production and survival (Heath 1987). Dioxins and furans were detected in ovarian tissues of shortnose sturgeon collected in the Sampit River/Winyah Bay ecosystem (South Carolina). Results showed that 4 out of 7 fish tissues analyzed contained tetrachlorodibenzo-p-dioxin (TCDD) concentrations > 50 ppt, a level which can adversely affect the development of sturgeon fry (J. Iliff, National Oceanic and Atmospheric Administration, Damage Assessment Center, Silver Spring, Maryland, unpublished data). In addition, this study indicated that TCDD concentrations were much more variable in wild shortnose sturgeon than in the hatchery-reared shortnose sturgeon used for reference.

Dams

Hydroelectric dams may affect shortnose sturgeon by restricting habitat, altering river flows or temperatures necessary for successful spawning and/or migration, and causing mortalities to fish that become entrained in turbines. In all but one of the northeast rivers supporting sturgeon populations (the exception being the "damlocked" population above the Holyoke Dam in the Connecticut River), the first dam on the river marks the upstream limit of the shortnose sturgeon population's range (Kynard 1997). In all of these rivers, shortnose sturgeon spawning sites occur just below the dams, leaving all life stages vulnerable to perturbations of natural river conditions (e.g., volume, flow velocity) caused by the dam's operation. Sturgeon appear unable to use some fishways (e.g., ladders) but have been lifted in fish lifts. For example, the Holyoke Dam fish lift in the Connecticut River passed 81 shortnose sturgeon in 20 years (Kynard in press).

An inability to move above dams and use potentially beneficial habitats may restrict population growth. Recent evidence from the Connecticut River (Kynard 1997), and the Cape Fear River (Moser and Ross 1995) suggests that pre-spawning adults may move upstream at a time when fish lifts or locks are not operating. Since sturgeon require adequate river flows and water temperatures for spawning, any alterations that dam operations pose on a river's natural flow pattern, including increased or reduced discharges, can be detrimental to sturgeon reproductive success. Additionally, dam maintenance activities, such as minor excavations along the shore, release silt and other fine river sediments that could be deposited in nearby spawning sites and degrade critical spawning habitat. Based on the cumulative impacts of the Edwards Dam (located below head-of-tide on the Kennebec River), the Maine Department of Marine Resources estimated that removal of this dam would increase production potential of the Kennebec River shortnose sturgeon population segment by 11% (NMFS 1996). Under the recent Lower Kennebec River Comprehensive Hydropower Settlement Accord, the Edwards Dam is scheduled to be dismantled in 1999.

Buckley and Kynard (1985a) suspected that the low-head Enfield Dam (Connecticut) was an incomplete barrier to sturgeon movements. Similarly, low elevation dams in the Southeast may also restrict or limit sturgeon access to natural spawning areas. In the Savannah River shortnose sturgeon are known to spawn downstream of the Augusta City lock and dam. A low elevation Lock and Dam on the Cape Fear River apparently blocks upstream migration of that river's shortnose sturgeon population (Moser and Ross 1995).

Dissolved Oxygen

Pulp mill, silvicultural, agricultural, and sewer discharges, which contain elevated temperatures or high biological demand, can reduce dissolved oxygen levels. In addition, reduced water flows resulting from power plant shut downs can produce anoxic conditions downstream (see Cooling Water Intakes/ Power Plant section below). Low oxygen levels (below 5 ppm) are known to be stressful to aquatic life, and presumably, sturgeon would be adversely affected by levels below this limit. Jenkins et al. (1993) found that juvenile shortnose sturgeon experienced relatively high mortality (86%) when exposed to dissolved oxygen concentrations of 2.5 mg/l. Older sturgeon (> 100 days) could tolerate dissolved oxygen concentrations of 2.5 mg/l with < 20% mortality, indicating an increased tolerance for lowered oxygen levels by older fish.

Shortnose sturgeon may be less tolerant of low dissolved oxygen levels in high ambient water temperatures and show signs of stress in water temperatures higher than 28^{o}C (Flournoy et al. 1992). At these temperatures, concomitant low levels of dissolved oxygen may be lethal. In Georgia, several rivers exhibit low oxygen levels (<2.5 mg/l) at the saltwater/freshwater interface, an area that normally aggregates both juveniles and adults (Rogers and Weber 1995b). Extremely low dissolved oxygen levels in the St. Marys and Satilla Rivers may explain the failure to capture shortnose sturgeon during recent sturgeon surveys in these systems (Rogers and Weber 1995b).

Dredging

Maintenance dredging of federal navigation channels can adversely affect or jeopardize shortnose sturgeon populations. In particular, hydraulic dredges (e.g., hopper) can lethally harm sturgeon by entraining sturgeon in dredge dragarms and impeller pumps. NMFS observers documented the take of one Atlantic sturgeon in a hopper dredge operating in King's Bay, Georgia (C. Slay, New England Aquarium, personal communication). In addition to direct effects, dredging operations may also impact shortnose sturgeon by destroying benthic feeding areas, disrupting spawning migrations, and filling spawning habitat with resuspended fine sediments. Potential impacts from hydraulic dredge operations may be avoided by imposing work restrictions during sensitive time periods (i.e., spawning, migration, feeding) when sturgeon are most vulnerable to mortalities from dredging activity. In 1991, the National Marine Fisheries Service concluded that an Army Corps of Engineers' (ACOE) maintenance dredging operation in the lower Connecticut River was likely to jeopardize the continued existence of the Connecticut River shortnose sturgeon population. This conclusion was based on the season in which the project was scheduled (early summer), the proposed use of a hydraulic hopper dredge, and in-river disposal within high use feeding areas. To avoid jeopardy, the NMFS recommended that the ACOE use alternative dredge types (i.e., clamshell, hydraulic pipeline) and/or reschedule the project when sturgeon were unlikely to be in the project area.

Several recent events demonstrate that, in addition to hydraulic hopper dredging, other dredging methods may also adversely affect sturgeon. Atlantic sturgeon were killed in both hydraulic pipeline (n=1) and bucket-and-barge operations (n=1) in the Cape Fear River (M.Moser, University of North Carolina-Wilmington, personal communication). Two shortnose sturgeon carcasses were discovered in a dredge spoil near Tullytown, Pennsylvania and apparently killed by a hydraulic pipeline dredge operating in the Delaware River in March, 1996 (B. McDowell, New Jersey Division of Fish and Wildlife, personal communication). Necropsy reports indicated that the skins of both fish were infused with silt **C** a pattern consistent with fish passing through a hydraulic pipeline dredge (J. Ziskowski, NMFS, personal communication). In early 1998, three shortnose sturgeon were killed by a hydraulic pipeline dredge operating in the Florence to Trenton section of the upper Delaware River (N. Haley, NMFS, personal communication).

Cooling Water Intakes/Power Plants

Shortnose sturgeon are susceptible to impingement on cooling water intake screens. Electric power and nuclear power generating plants can affect sturgeon by impinging larger fish on cooling water intake screens and entraining larval fish. Power plant construction and operation activities such as excavation, dewatering, and dredging may adversely affect sturgeon habitat by producing excessive levels of turbidity and destroying habitat and prey resources. Without better data on current population sizes, it is not possible to assess the extent to which power plant impacts adversely affect a given sturgeon population.

The operation of power plants in the upper portions of rivers has the greatest potential for directly affecting sturgeon populations because of the increased incidence of entraining younger and more vulnerable life stages. Documented mortalities of sturgeon have occurred in the Delaware, Hudson, Connecticut, Savannah and Santee rivers. Between 1969 and 1979, 39 shortnose sturgeon were impinged at power plants in the Hudson River (Hoff and Klauda 1979). Approximately 160 shortnose sturgeon were estimated to be impinged on intake screens at the Albany Steam Generating Station (Albany, NY) between October 1982 and September 1983 (E. Radle, New York State Department of Environmental Conservation, personal communication). No shortnose sturgeon impingements have been reported at this station since 1985 (LMS 1991).

Eight shortnose sturgeon were discovered on the intake trash bars of the Salem Nuclear Generating (SNG) Station in the Delaware River between June, 1978 and November, 1992 (NMFS 1993). All of these fish were adults ranging from 54 to 99 cm FL. Younger fish can pass through the SNG Station's trash racks and become impinged on travelling screens, although these incidents have not been documented (Nuclear Regulatory Commission (NRC) 1980). Estimated annual losses of shortnose sturgeon due to impingement at the SNG station are between 0 and 11 fish (NRC 1980).

The operation of power plants can have unforeseen and extremely detrimental impacts to water quality. The St. Stephen Power Plant near Lake Moultrie, South Carolina was shut down for several days in June, 1991, when large mats of aquatic plants entered the plant's intake canal and clogged the cooling water intake gates. Decomposing plant material in the tailrace canal coupled with the turbine shut down (allowing no flow of water) triggered a low dissolved oxygen water condition downstream and a subsequent fish kill. The South Carolina Wildlife and Marine Resources Department reported that 20 shortnose sturgeon were killed during this die-off.

Reservoir Operation

The ACOE=s operation of reservoirs in major rivers may impact sturgeon by altering natural river flow rate and volume. Unplanned but controlled reservoir releases can diminish or reduce sturgeon spawning success by artificially extending high flow periods during the time when water temperatures reach ideal ranges for spawning. In addition, abrupt termination of high discharge periods during summer can result in lethal anoxic conditions downstream (P. Kornegay, North Carolina Wildlife Resources Commission, personal communication).

Thermal refuges

During summer months, especially in southern rivers, shortnose sturgeon must cope with the physiological stress of water temperatures that often exceed 28^{o}C. Flournoy et al. (1992) suspected that, during these periods, shortnose sturgeon congregate in river regions which support conditions that relieve physiological stress. In southern rivers where sturgeon movements have been tracked, sturgeon refrain from moving during warm water conditions and are often captured at release locations during these periods (Flournoy et al. 1992; Rogers and Weber 1994; Weber 1996). Gulf sturgeon (*A. o. desotoi*) are reported to fast at high water temperatures and occupy river reaches of the Suwannee River (Florida) near flowing spring heads (Mason and Clugston 1993). Flournoy et al. (1992) suggest that, in the Altamaha River, shortnose sturgeon also seek deep, artesian spring-fed habitats which provide thermal refugia.

Although a relatively new finding, the loss and/or manipulation of these discrete habitats may limit or be limiting population survival, particularly in southern river systems. For instance, Krause and Randolph (1989) report that subterranean aquifers are severly depleted in the Savannah and Ogeechee Rivers (Georgia) and Satilla and St. Marys Rivers (Florida). These systems either exhibit signs of juvenile mortality (Savannah: Collins and Smith 1993; Ogeechee: Rogers and Weber 1994, Rogers and Weber 1995b, Weber 1996) or no longer appear to support shortnose sturgeon populations (Satilla and St. Marys: Rogers and Weber 1995b).

Introductions and Transfers

The effects of introduced species on shortnose sturgeon are unknown. However, the rapid increases in abundance of non-indigenous species (e.g., Asian clams, zebra mussels, blue and flathead catfish) in some rivers is likely to adversely affect sturgeon prey and/or introduce new predators and competitors of shortnose sturgeon. Introductions and transfers of indigenous and nonindigenous sturgeon, intentional or accidental, may threaten wild shortnose sturgeon populations by imposing genetic threats, increasing competition for food or habitat, or spreading diseases. Sturgeon species are susceptible to viruses enzootic to the west coast and fish introductions could further spread these diseases.

RECOVERY

Recovery Strategy

The long-term recovery objective for the shortnose sturgeon is to recover all discrete population segments to levels of abundance at which they no longer require protection under the ESA. Each population segment may become a candidate for downlisting when it reaches a minimum population size that: 1) is large enough to prevent extinction, and 2) will make the loss of genetic diversity unlikely. This minimum population size for each population segment has not yet been determined. Therefore, establishing endangered and threatened population size thresholds is a priority 1 recovery task specified in the succeeding Recovery Narrative section. To achieve and preserve minimum population sizes for each population segment, essential habitats must be identified and maintained, and mortality must be monitored and minimized. Accordingly, other key recovery tasks are to define essential habitat characteristics, assess mortality factors, and protect shortnose sturgeon through applicable federal and state regulations.

Recovery task priorities vary among population segments because not all segments experience the same sets of problems or receive the same level of research. Even though shortnose sturgeon were listed under the ESA over 20 years ago, population dynamics and distribution data are lacking for many population segments. A rangewide genetic assessment and reliable estimates of population size, age structure, and recruitment are needed to review the status of each population segment. In many river systems (e.g., Penobscot, Chesapeake, Satilla, St. Johns) there are relatively recent records of shortnose sturgeon occurrence, but no information on their distribution or abundance levels. Obtaining this information is a high priority for such rivers. In contrast, assessments of growth, reproductive success, and anthropogenic impacts are needed for relatively well-studied population segments (e.g., Delaware, Hudson, Connecticut). Research activities may be important for a single population segment, several population segments, or rangewide. Therefore, the SSRT designed an Implementation Schedule that specifies recovery task priorities for each population segment and suggests recovery tasks which may be conducted most cost-effectively on a rangewide or regional basis.

What follows is a step-down outline for each of the three shortnose sturgeon recovery objectives, a narrative that summarizes the components of each objective, and a summary list of recovery tasks needed to implement objectives. The recovery outline follows a standard format; numbers corresponding to each of the objectives, subobjectives, and recovery tasks denote their place in the outline not their relative priority. Individual recovery tasks are prioritized in the succeeding Implementation Schedule.

Recovery Outline

1. ESTABLISH LISTING CRITERIA

1.1 Determine the size of shortnose sturgeon population segments for listing and evaluate trends in recruitment

1.1.1 Genetic considerations

1.1.2 Identify variability within shortnose sturgeon population segments

1.1.3 Evaluate population segment stability

1.1.4 Survey for shortnose sturgeon in rivers where they historically occurred

1.2 Determine minimum habitat for shortnose sturgeon population segments

1.2.1 Limiting effects of spawning, rearing, and adult habitats

1.2.2 Criteria for essential habitat identification

1.3 Determine maximum allowable mortality for shortnose sturgeon population segments

1.3.1 Allowable take authorized by the ESA

1.3.2 Guidance for mortality in the case of de-listing

2. PROTECT SHORTNOSE STURGEON POPULATIONS AND HABITATS

2.1 Ensure agency compliance with the ESA

2.2 Reduce bycatch of shortnose sturgeon

2.2.1 Minimize the effects of incidental capture of shortnose sturgeon

2.2.2 Increase enforcement of the ESA and state fisheries restrictions

2.3 Determine if critical habitat designations are prudent for shortnose sturgeon population segments

2.4 Mitigate/eliminate impact of adverse anthropogenic actions on shortnose sturgeon population segments

2.4.1 Mitigate impacts of modifications to important habitat and other destructive activities

2.4.2 Study the effects of point and nonpoint source pollution on shortnose sturgeon and reduce harmful levels

2.4.3 Identify introduced species and stock transfers that may affect shortnose sturgeon or their habitat and take actions to control or eliminate these threats

2.5 Formulate a public education program to increase awareness of shortnose sturgeon and their status

2.6 Coordinate federal, state, and private efforts to implement recovery tasks

3. REHABILITATE HABITATS AND POPULATION SEGMENTS

3.1 Restore habitats and their functions in the life histories of each population segment

3.1.1 Restore access to habitats

3.1.2 Restore spawning habitat and conditions

3.1.3 Restore foraging habitat

3.1.4 Reduce deleterious contaminant concentrations

3.1.5 Resolve project conflicts that potentially impact shortnose sturgeon or their habitat

3.2 Develop a breeding and stocking protocol for shortnose sturgeon

3.3 Reintroduce shortnose sturgeon into river ecosystems where they have been extirpated

3.4 Assess the need for augmentation

Recovery Narrative

1. ESTABLISH LISTING CRITERIA

Criteria are needed to assess the appropriate listing status of each shortnose sturgeon population segment. Currently, all shortnose sturgeon population segments are listed as endangered. Change

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following biological factors: evaluation of population segment size and dynamics, assessment of essential habitat, and identification of sources of mortality.

1.1 Determine the size of shortnose sturgeon population segments for listing and evaluate trends in recruitment

A minimum population size below which a shortnose sturgeon population segment is in danger of going extinct should be determined (i.e., an endangered threshold). This population size should reflect the reproductive and genetic characteristics of a population segment. Therefore, the threshold should be sufficiently large enough to maintain genetic diversity and avoid extinction. The loss of population heterogeneity may not pose an immediate threat to a population segment, but may limit its ability to cope with future environmental change. A measure of population size, for example, the number of spawning fish, could indicate that a population is below an established threshold and in jeopardy of extinction or genetic damage. Successive estimates of the population segment should be evaluated to determine if the population is above or below the threshold for an endangered population.

A minimum population size below which a shortnose sturgeon population segment is likely to become endangered (i.e., threatened threshold) should also be developed. This threshold should reflect sturgeon reproductive potential and represent a population of sufficient size that levels of natural mortality likely to be experienced by the population segment will not depress the population below the endangered threshold. Consistent with the theoretic grounds for determining this level, the threshold for a threatened population would be suitable for a delisted population with zero harvestable surplus. A formula should be developed to weigh successive estimates of the population to determine if a population is above or below the threshold for a threatened population.

The demographics of a population segment should be examined to determine if the population size is stable or increasing, and if recruitment is sufficient to replace spawners. In the absence of time series fisheries data, it may be necessary to examine successive population estimates and/or single assessments of age structure to judge whether a population segment is stable or increasing.

In summary, the threshold for an endangered population would represent a level below which the population segment is in danger of going extinct, or of sustaining genetic damage that could lead to extinction. The threshold for a threatened population would represent a level where common perturbations would not be expected to send the population below the endangered threshold. Finally, population dynamics data must be considered together with population size estimates to determine whether a population segment is replacing itself or increasing in size.

1.1.1 Genetic considerations

The shortnose sturgeon's genome, reproductive potential, and reproductive success are all considerations in setting thresholds for endangered and threatened population sizes. The endangered threshold should be sufficiently high to avoid catastrophic extinction (Lande 1993; Lynch and Lande 1993), genetic damage due to loss of rare alleles or inbreeding (Nei et al. 1975; Allendorf 1986; Hedrick 1992) or Allee effects (depensation effects at low population density) (Asmussen 1979; Dennis 1989). Thomas (1990) reviewed threatened and endangered population data from several vertebrate species and established general estimates of minimum viable population sizes: abundance levels that "would be likely to permit medium- to long- term persistence." These population sizes may be used in considering thresholds for shortnose sturgeon population segments (NMFS 1996). Determining minimum population sizes for viable populations is an active area of investigation (Thompson 1991; Caughley 1994; National Research Council 1995); the SSRT recommends researching the appropriate thresholds for use with shortnose sturgeon populations.

1.1A*[2] Conduct a rangewide genetic assessment of shortnose sturgeon

[2] a * denotes specific recovery/research tasks associated with recovery objectives

1.1B* Determine abundance, age structure, and recruitment of shortnose sturgeon population segments

1.1C* Determine endangered and threatened population size thresholds for shortnose sturgeon population segments

1.1.2 Identify variability within shortnose sturgeon population segments

Shortnose sturgeon productivity varies both spatially and temporally. Thus, population segment size thresholds should be: 1) adjusted according to local population characteristics; and 2) based on models that simulate the variability of shortnose sturgeon populations over time. Although it may be possible to use the same thresholds for several population segments, the best available shortnose sturgeon population model, that incorporates age structure and recruitment data, should be tested on each population segment over a meaningful number of iterations.

1.1.3 Evaluate population segment stability

Techniques should be developed to analyze trends within shortnose sturgeon population segments to determine if population sizes are stable or increasing. These assessments should be based on fisheries independent data and require either successive population estimates and/or analysis of population segment age structure. These data and the population size estimates should be used to conduct a status review for each population segment.

1.1D* Conduct a status review for each population segment

1.1.4 Survey for shortnose sturgeon in rivers where they historically occurred

In some rivers, shortnose sturgeon have been "discovered" in recent years, even though they probably have existed in these systems for some time, but were not captured in routine fish surveys. Sturgeon habitats are difficult to sample and sturgeon are most susceptible to gear types (gillnets, trammel nets) that are seldom used in standardized fish sampling surveys. For these reasons, sampling directed toward the capture of shortnose sturgeon should be conducted in all river systems where they historically occurred but have not been recorded in recent time. This will confirm that the species is extirpated in these systems and not overlooked due to inappropriate sampling.

1.1E* Develop a standardized sampling protocol and determine minimum sampling required to assess presence of shortnose sturgeon

1.1F* Sample for shortnose sturgeon in rivers where they historically occurred

1.2 Determine minimum habitat for shortnose sturgeon population segments

Sizes and recruitment of fish populations are affected by a variety of factors including climate change, variability in annual fecundity, and habitat availability. Given these factors, it is possible that an endangered shortnose sturgeon population segment may regularly exceed the capacity of a habitat area, if the amount of habitat is based on the threshold for an endangered population. In this event, population segment growth would be arrested and there would be little, if any, potential for recovery. Consequently, the recovery team recommends establishing a minimum habitat size that accommodates the life cycle of a de-listed population segment.

1.2.1 Limiting effects of spawning, rearing, and adult habitats

Essential habitat should encompass the habitat requirements of all shortnose sturgeon life stages. For example, habitat and its associated forage base may not limit growth and reproduction of adult fish but the lack of suitable nursery habitat may create a recruitment bottleneck. A complete understanding of shortnose sturgeon habitat requirements and potential habitat limitations is necessary for determining minimum essential habitat for shortnose sturgeon populations.

1.2.2 Criteria for essential habitat identification

Specific criteria must be established for all essential shortnose sturgeon habitats: spawning and rearing sites, feeding locations, and overwintering/summering concentration areas. Recent research indicates that these criteria may differ for southern and northern populations or even for individual drainages. For example, deep thermal refuges may be important habitat for southern population segments but are not necessary for survival of northern populations. Shortnose sturgeon make seasonal movements between spatially separated, but distinct, habitats. Therefore, Geographic Information System (GIS) maps may be important tools for organizing information needed to establish essential habitat characteristics. In particular, the SSRT recommends constructing GIS maps of sturgeon concentration areas based on field observations and physiological requirements (established in the laboratory using cultured fish). Essential habitat zones for each population segment could be identified using these maps.

Shortnose sturgeon inhabit river/estuarine systems that are static in some physical attributes and dynamic in others. For example, units of preferred bottom substrate for spawning are not likely to change rapidly over time, unless dredged or similarly manipulated. Conversely, a required salinity zone that supports preferred foods or provides a physiological refuge may change relative position and extent in response to tidal action and variation in river discharge. Shortnose sturgeon also migrate over great distances in large river systems, occupying some river reaches for a relatively short time. Consequently, essential habitat identification for this species will require careful consideration of many complex variables.

1.2A* Conduct field research (mark-recapture, telemetry, survey sampling, etc.)

to document shortnose sturgeon seasonal distribution and map concentration areas to characterize essential habitat

1.2B* Conduct laboratory experiments, using cultured fish, to study behavior patterns, habitat/food preferences, and physiological tolerances

1.2C* Develop criteria to identify essential habitat

1.3 Determine maximum allowable mortality for shortnose sturgeon population segments

The mortality factors for each population segment should be evaluated. If mortality factors are expected to keep a population below the endangered or threatened population threshold, then the population should remain listed. If expected mortality factors are unlikely to reduce a population below a listing status threshold, then the population should be evaluated to determine whether it qualifies for downgrading to threatened or should be delisted. Conversely, de-listed or threatened population segments may require upgrading to endangered status if unforeseen mortality factors push these populations below either the threatened or endangered listing thresholds.

1.3.1 Allowable take authorized by the ESA

Cumulative allowable take, permitted under the ESA, should be reviewed for each listed shortnose sturgeon population segment. The NMFS should insure that allowable take will not significantly affect the recovery of a population segment.

1.3.2 Guidance for mortality in the case of de-listing

Shortnose sturgeon are a long-lived species with limited reproductive potential. The species cannot tolerate the high levels of exploitation associated with sturgeon fisheries at the turn of the century when sturgeon stocks collapsed. Many attributes of shortnose sturgeon life history (e.g., delayed maturation, non-annual spawning, and low fecundity (relative to other fishes)) hinder early detection of population declines and, consequently, limit the effectiveness of retaliative management measures. Therefore, when shortnose sturgeon populations are delisted, fishery managers must acknowledge the potential for sturgeon populations to experience seemingly rapid, precipitous declines in abundance. Further, delisting a shortnose sturgeon population segment should not constitute a mandate for harvest, particularly in cases where opening the fishery in one river could provide a market for fish harvested illegally in other rivers. While healthy sturgeon populations may sustain minimum levels of utilization, directed harvest of shortnose sturgeon should not occur without careful consideration of other sources of sturgeon mortality and characteristics of the species= life history.

1.3A* Assess mortality factors and define take limits for shortnose sturgeon population segments

2. PROTECT SHORTNOSE STURGEON POPULATIONS AND HABITATS

2.1 Insure agency compliance with the ESA

All federal agencies funding, authorizing or conducting activities where shortnose sturgeon occur must fulfill their responsibilities under Section 7(a)(1) and Section 7(a)(2) of the ESA. As a co-administrator of the ESA, the NMFS should insure that the protective actions and regulatory requirements of the ESA safeguard against impacts and mortalities to shortnose sturgeon. The NMFS should inform federal agencies of their responsibilities under the ESA and encourage federal agencies to adopt programs that support shortnose sturgeon recovery. This should include supporting research that identifies potential impacts (to shortnose sturgeon) resulting from specific development projects.

In addition, the NMFS should establish Section 6 cooperative agreements with appropriate states to promote increased state oversight of sturgeon conservation activities and provide a funding resource for state agents to conduct research on shortnose sturgeon. State actions may include identifying shortnose sturgeon habitat within state Coastal Zone Management Plans, promotion of Best Management Practices to reduce non-point source impacts, and consideration of shortnose sturgeon in State Pollution Discharge Elimination Systems permits to reduce point-source impacts and minimize/eliminate incidental takes.

2.1A* Establish Section 6 Cooperative agreements with states where shortnose sturgeon occur

2.1B* Encourage federal agencies to fulfill their responsibilities under Section 7(a)(1) of the ESA and support conservation programs or research to advance shortnose sturgeon recovery

2.1C* Insure that actions authorized, funded or conducted by federal agencies do not jeopardize the continued existence of shortnose sturgeon, as required by Section 7(a)(2) of the ESA

2.2 Reduce bycatch of shortnose sturgeon

2.2.1. Minimize the effects of incidental capture of shortnose sturgeon

Fisheries that incidentally capture shortnose sturgeon should be identified. Estimates of shortnose sturgeon mortality resulting from incidental capture should be obtained and sub-lethal effects of capture and release should be assessed for each fishery. Based on these results, guidelines should be developed to reduce shortnose sturgeon bycatch mortality and sub-lethal effects. If necessary, the fishery should be regulated to minimize the impacts of capture. For example, impose seasonal or areal limits on problem fisheries (e.g., shad gillnet fishery) to reduce the likelihood of incidental capture, restrict or eliminate certain gear types, and inform fishermen of recommended handling procedures to reduce mortality.

2.2A* Assess shortnose sturgeon mortality from incidental capture and document characteristics of fisheries that impact shortnose sturgeon (gear types, fishing season and location, fishing effort, etc.)

2.2B* Conduct research to determine sub-lethal effects of incidental capture and develop guidelines to minimize bycatch mortality and sub-lethal effects (i.e. reduce soak times, reduce handling time, gear modification, etc.)

2.2.2 Increase enforcement of the ESA and state fisheries restrictions

Section 9 of the ESA prohibits capturing, hunting, injuring, selling or attempting any of the above on shortnose sturgeon, unless covered by one of the ESA's take exemptions. Local enforcement officers should know how to identify shortnose sturgeon, where shortnose sturgeon occur, and in which fisheries or activities they are susceptible to capture or mortality. Genetic analysis of shortnose sturgeon tissue can aid in the identification of sturgeon products that are marketed illegally. Fishery restrictions that protect shortnose sturgeon and the penalties that may result from violations should be widely publicized to discourage the directed take of shortnose sturgeon. Officers of the court should also be alerted to the seriousness of crimes involving endangered species. For example, a U.S. District judge in 1995 sentenced two South Carolina fishermen to home detention and fined each man $500.00 for taking two live shortnose sturgeon and five pounds of roe (D. Cooke, S.C. Dept. of Natural Resources, Bonneau, S.C., personal communication). Such light sentences do not convey the message that Section 9 violations are a serious crime.

2.2C* Increase enforcement of laws protecting shortnose sturgeon

2.2D* Use cultured fish to develop genetic markers to identify illegally-marketed shortnose sturgeon products

2.3 Determine if critical habitat designations are prudent for shortnose sturgeon population segments

For each population segment, critical habitat should be identified and designations promulgated, if prudent, based on generalized criteria and local observations of habitat use (as outlined in 1.2). Periodic surveys of any designated critical habitat should be conducted to confirm shortnose sturgeon use of designated areas. The critical habitat designations should be updated on a 5-year cycle to reflect any changes in sturgeon habitat use (as indicated by field research).

2.3A* Identify and, if prudent, designate critical habitat for shortnose sturgeon population segments

2.3B* Conduct field research to document shortnose sturgeon use of any designated critical habitats and to identify changes in habitat use that would affect critical habitat designations

2.4 Mitigate/eliminate impact of adverse anthropogenic actions on shortnose sturgeon population segments

Human actions that adversely affect shortnose sturgeon include: 1) activities that modify or destroy important habitats and/or kill sturgeon, and 2) introduction of non-native species that disturb ecosystems upon which shortnose sturgeon depend.

2.4.1 Mitigate impacts of modifications to important habitat and other destructive activities

Activities such as dredging, bridge construction, power plant operation, in-river disposal, dam operation and maintenance affect shortnose sturgeon both directly and indirectly (see Factors Affecting Recovery). These activities should be mitigated or eliminated (if possible). For proposed or re-licensed spillways or dams, mitigation may include providing fish passage devices or structure breaches. Blasting should be avoided whenever possible, unless suitable protective measures can be implemented. While dredging and in-river disposal cannot be eliminated in rivers with ACOE Federal Navigation Projects, a number of mitigation alternatives exist: 1) limit dredging windows to non-critical periods, 2) restrict use of in-river disposal sites, and/or 3) use equipment or techniques that minimize impact to sturgeon and their habitat. Effects of entrainment and impingement in river intakes (cooling water, hydroelectric or hydrochemical turbines, dredges, etc.) can be mitigated by requiring adequate screening of intake water or limiting the time period, location, or volume of water withdrawals. Researching all of these impacts will refine and increase the number of mitigation alternatives.

2.4A* Insure that fish passage devices on all proposed and re-licensed structures allow adequate passage of shortnose sturgeon and do not alter migration or spawning behavior

2.4B* Conduct research to assess the direct and indirect effects of blasting, dredging, and in-river disposal on all life stages of shortnose sturgeon

2.4C* Compare impacts of various dredging, blasting and disposal techniques and equipment on shortnose sturgeon and their habitat to minimize the detrimental effects of these activities

2.4D* Conduct research to assess shortnose sturgeon mortality from entrainment and impingement and maximize efforts to obtain scientific information from dead fish

2.4.2 Study the effects of point and nonpoint source pollution on shortnose sturgeon and reduce harmful levels

The degree of organic and inorganic contaminant loads in sturgeon tissue, food, and habitats should be assessed throughout the range of this species. The effects of contaminants (using realistic levels) on shortnose sturgeon growth, survival, and reproduction should be evaluated using cultured shortnose sturgeon. Areas that undergo either acute or chronic hypoxia, which may directly or indirectly impact shortnose sturgeon, should be identified. Point and nonpoint sources of contaminants, nutrient loads, or thermal effluents that significantly lower dissolved oxygen in shortnose sturgeon habitat (i.e., pulp and paper mills, silvicultural and agricultural runoff, power plants, municipal wastewater, etc.) should be reduced or, if possible, removed.

2.4E* Analyze shortnose sturgeon tissue, food items, and sediment/water samples from shortnose sturgeon habitat to assess the degree of contaminant loading

2.4F* Determine the effects of contaminants on shortnose sturgeon growth, survival, and reproduction using cultured fish

2.4G* Collect continuous recordings of dissolved oxygen in shortnose sturgeon habitat to identify the extent and duration of hypoxic events

2.4H* Use cultured shortnose sturgeon to determine the species' tolerance for low dissolved oxygen levels under a variety of temperature and salinity conditions and assess the sublethal effects of hypoxia

2.4.3 Identify introduced species and stock transfers that may affect shortnose sturgeon or their habitat and take actions to control or eliminate these threats

Introduced species and stock transfers that are predators, competitors or parasites of shortnose sturgeon, or that may facilitate the spread of sturgeon diseases, need to be identified. In addition, the incidence of disease in the wild should be assessed for all population segments. If the impacts of non-indigenous species on shortnose sturgeon are significant, efforts should be made to control introductions or transfers of these species and if necessary, eliminate them. In addition, by working with individual states, the risks of proposed introductions of non-native species in the shortnose sturgeon's range can be assessed.

2.4I* Determine the extent of parasitism, disease, competition for resources and direct mortality to shortnose sturgeon resulting from introduced species and stock transfers

2.5 Formulate a public education program to increase awareness of shortnose sturgeon and their status

The NMFS should generate public interest in sturgeon and sturgeon recovery by contacting media outlets, suggesting feature stories, and using existing forums for educating the public (e.g., public aquaria, FWS Partners for Wildlife Program, private foundations). Articles, posters, and pamphlets should be published to increase public knowledge of shortnose sturgeon and their unique and complex life history. This information may include identifiable features of the species, listing status, range, susceptibility to incidental captures, and a number or address to report sightings or captures. Cultured shortnose sturgeon should be placed in aquariums and zoos to increase public awareness of the species and its plight.

2.5A* Educate the public and heighten awareness of shortnose sturgeon issues by printing and distributing articles, posters and pamphlets. Make cultured shortnose sturgeon available to aquariums and zoos

2.5B* Update the public on recovery efforts by working with the media to publish articles featuring shortnose sturgeon research and conservation efforts

2.5C* Work with schools to develop and evaluate educational materials and curricula that introduce students to sturgeons, the river/estuarine environment, and the ESA

2.6 Coordinate federal, state and private efforts to implement recovery tasks

A Recovery Coordinator and a Recovery Implementation Team, or several regional Implementation Teams, should be appointed to stimulate implementation of recovery tasks and focus recovery objectives within specific regions. The Recovery Coordinator should establish a means, or maintain an existing forum (e.g., *Sturgeon Notes*), for communicating shortnose sturgeon research results, management/recovery actions, and availability of recent publications. The Recovery Coordinator will also be responsible for monitoring recovery progress and seeking funds to reach the ultimate goal of de-listing all shortnose sturgeon population segments. The Recovery Coordinator could advance sturgeon conservation by identifying potential funding sources for sturgeon research proposals and investigating long-term strategies to support sturgeon recovery needs. Using the Implementation Schedule, the Recovery Coordinator should bring together researchers seeking funding with agencies responsible for funding proposed research activities.

2.6A* Appoint a Recovery Coordinator and establish regional Recovery Plan Implementation Teams to stimulate implementation of recovery plan objectives among constituents and cooperating agencies

2.6B* Establish a communication network for exchanging research results and highlighting recovery actions

2.6C* Seek funding for shortnose sturgeon recovery activities

2.6D* Complete periodic updates of the Recovery Plan to reflect current status of population segments, factors affecting recovery, and priority recovery objectives

3. REHABILITATE HABITATS AND POPULATION SEGMENTS

3.1 Restore habitats and their functions in the life histories of each population segment

3.1.1 Restore access to habitats

Various barriers (hydroelectric dams, lock-and-dam, etc.) exist on some river mainstems presently inhabited by shortnose sturgeon. These facilities can prevent adult fish from reaching historical upstream spawning habitat and injure adults and juveniles during downstream migration. Providing access to habitats and minimizing delay and injury of migrants at both operating and abandoned facilities should be a priority. Restoring access to habitats may involve removal of abandoned barriers or providing up- and downstream fish passage facilities.

3.1A* In each river, identify natural migration patterns of each life stage and any barriers to movement between habitats. Devise methods to pass shortnose sturgeon above/below existing barriers

3.1.2 Restore spawning habitat and conditions

The amount and timing of river discharge is regulated by facilities on many rivers; that is, flows during spawning may not be natural. As spawning timing and locations are identified in these regulated rivers, flows that create acceptable spawning conditions should be maintained during the spawning period. Thus, the operating plans for hydroelectric generating facilities and flood storage reservoirs should include special conditions to protect shortnose sturgeon.

Mainstem rivers are continually impacted by point and non-point activities that increase sediment levels entering rivers. Spawning substrate should be protected from activities that can degrade substrate composition (e.g., fine sediment level increases and reduction of crevices). When prevention fails and substrate is degraded, natural rehabilitation or artificial rehabilitation should be evaluated using appropriate methods (regulated flows or addition of new material).

3.1B* Examine the relationships between river discharge level (and the correlated bottom water velocity), substrate type, and shortnose sturgeon spawning success

3.1C* Investigate the relationship between spawning substrate characteristics and shortnose sturgeon reproductive success. Conduct field experiments that: (1) evaluate the ability of natural river discharge to remove sediment and debris from spawning substrate; and (2) evaluate the acceptability of artificial substrate to spawning females

3.1D* Restore flows, in regulated rivers, during spawning periods to promote spawning success and rehabilitate degraded spawning substrate

3.1.3 Restore foraging habitat

Activities that can alter substrate type, such as damming, dredging, bridge construction, etc., can degrade foraging habitat. Basic knowledge of diet and feeding for all life stages is needed to assess the importance of feeding stations and movement between them (i.e., downstream movement of northern fish to saline areas in May-June). If foraging habitat is lost, activities should be modified to enable natural rehabilitation. If natural rehabilitation is impossible, suitable habitat restoration manipulations should be implemented.

3.1E* Investigate satisfactory methods for examining diet

3.1F* Determine rangewide diet, foraging ecology and growth, for each shortnose sturgeon life stage. In populations with poor growth, examine foraging habitat characteristics and conduct experimental manipulations, if appropriate, to restore habitat

3.1.4 Reduce deleterious contaminant concentrations

The levels of contaminants in shortnose sturgeon should be evaluated. Additionally, the identification of harmful contaminants and the specific levels at which contaminants are deleterious to sturgeon should be a research focus. Presently, there is insufficient information to develop recovery actions relative to many contaminants. In southern rivers, oxygen-demanding contaminants may limit over-summering habitat. Although there is sufficient information to model loading of oxygen-demanding contaminants in many rivers (e.g., Savannah, Ogeechee, Satilla, St. Marys), continued research on these substances is necessary. Recovery actions to reduce loading of oxygen-demanding contaminants in the above-listed systems should be a high priority.

3.1G* If contaminants are directly or indirectly responsible for loss of shortnose sturgeon fitness, identify contaminant or oxygen demanding sources and reduce loading.

3.1.5 Resolve project conflicts that potentially impact shortnose sturgeon or their habitat

Management and manipulation of river and estuary ecosystems is the responsibility of several federal agencies whose missions often conflict.

3.1H* Establish consistent operating policies that allow federal agencies to meet mission goals while protecting shortnose sturgeon and their habitats

3.2 Develop a breeding and stocking protocol for shortnose sturgeon

A breeding and stocking protocol is needed to insure that the best possible practices are used in the production of shortnose sturgeon for stocking, when and if NMFS determines that stocking is necessary for recovery purposes. The protocol must be consistent with any NMFS policy on artificial propagation of threatened and endangered species under the ESA. Generally, procedures should follow the "Breeding and Stocking Protocol for Cultured Atlantic Sturgeon" (Atlantic States Marine Fisheries Commission (ASMFC), 1996). Culture practices should duplicate known natural conditions (i.e., mating ratios should involve 3-7 males:1 female, with each male fertilizing a separate portion of the eggs as would occur in the wild). Donor stocks should be carefully selected to best match the life history of fish from the recipient system and minimize impacts of stocked fish that stray into areas where wild shortnose sturgeon occur.

3.2A* Develop a Shortnose Sturgeon Breeding and Stocking Protocol

3.3 Reintroduce shortnose sturgeon into river ecosystems where they have been extirpated

In some river systems shortnose sturgeon may be so rare that a population is functionally extirpated. To guide restoration efforts, the minimum population size below which restoration would be considered needs to be established. If rigorous and appropriate sampling indicate that shortnose sturgeon have been extirpated from a river where they historically occurred, then cultured sturgeon may be re-introduced if sufficient habitat is available for all life stages and if NMFS determines that reintroduction is appropriate. Fish should be cultured using the protocol developed for this species (see 3.2). All stocked fish should be tagged to allow monitoring of survival, movement, and growth. Reintroductions should ONLY be conducted when funds are available to monitor the success of the restoration effort via a carefully designed study that is approved by the NMFS and a Recovery Implementation Team.

3.3A* Use the standardized sampling protocol (1.1E*) to determine whether re-introductions may be needed

3.3B* Determine minimum population size below which restoration may be considered

3.3C* Monitor survival, movement patterns, distribution, foraging, and reproduction of stocked shortnose sturgeon. Use this information to evaluate the success of population restoration

3.4 Assess the need for augmentation

When a population segment has unusually low abundance of spawning adults or juveniles relative to available critical habitat (as judged by the NMFS or a Recovery Implementation Team), causes for the low abundance should be determined. If the problem is related to a correctable habitat condition, the problem should be remedied in a timely manner to save the population segment from extinction. Short-term stocking of cultured fish should only be used to supplement an existing population when this is the only reasonable manipulation that can prevent loss of the population; that is when the population is in imminent danger of extirpation and/or habitat conditions cannot be improved in a timely manner.

The SSRT recommends that cultured shortnose sturgeon be used to augment existing population segments under very specific circumstances. The tremendous potential for damage to the genetic architecture of existing population segments demands that extreme caution be used in augmentation efforts.

The SSRT supports augmentation only under the following set of conditions: 1) a breeding and stocking protocol, approved by the NMFS, is available to guide breeding and stocking programs; 2) an existing population segment is in imminent danger of extirpation; 3) essential habitats are functional but inaccessible to shortnose sturgeon; 4) an obstruction to movement cannot be removed in time to prevent extirpation; 5) cultured fish from the natal population are available; and 6) short-term stocking is the only reasonable measure to prevent loss of the population segment. These conditions may be met, for example, in cases where physical barriers that could be removed cause total recruitment failure year after year. Any stocking effort must be approved by the NMFS and a Recovery Implementation Team. In contrast to the ASMFC Breeding and Stocking Protocol for Atlantic Sturgeon (1996), stocking of shortnose sturgeon should be conducted for only a brief period to minimize potential effects of stocked fish on the wild stock. During this time, a high priority should be to minimize or eliminate those factors that caused the low abundance of shortnose sturgeon. All stocked fish must be tagged to allow ease of future identification and allow comparisons of the population dynamics and behavior of stocked fish to wild shortnose sturgeon. This information should then be used to guide any future augmentation programs.

3.4A* Assess the need for augmenting shortnose sturgeon population segments with stocked fish

Recovery Task Summary

The following is a summary list of shortnose sturgeon recovery/research tasks. Tasks are listed in the order in which they appear in the "Recovery Narrative" section and not in order of importance. Tasks are prioritized in the "Implementation Schedule" to reflect rangewide and river specific priority recovery and research needs.

1.1A* Conduct a rangewide genetic assessment of shortnose sturgeon

1.1B* Determine abundance, age structure, and recruitment of shortnose sturgeon population segments

1.1C* Determine endangered and threatened population size thresholds for shortnose sturgeon population segments

1.1D* Conduct a status review for each population segment

1.1E* Develop a standardized sampling protocol and determine minimum sampling required to assess presence of shortnose sturgeon

1.1F* Sample for shortnose sturgeon in rivers where they historically occurred

1.2A* Conduct field research (mark-recapture, telemetry, survey sampling, etc.) to document shortnose sturgeon seasonal distribution and map concentration areas to characterize essential habitat

1.2B* Conduct laboratory experiments using cultured fish to study behavior patterns, habitat/food preferences, and physiological tolerances

1.2C* Develop criteria to identify essential habitat

1.3A* Assess mortality factors and define take limits for shortnose sturgeon population segments

2.1A* Establish Section 6 Cooperative agreements with states where shortnose sturgeon occur

2.1B* Encourage federal agencies to fulfill their responsibilities under Section 7(a)(1) of the ESA and support conservation programs or research to advance shortnose sturgeon recovery

2.1C* Insure that actions authorized, funded, or conducted by federal agencies do not jeopardize the continued existence of shortnose sturgeon, as required by Section 7(a)(2) of the ESA

2.2A* Assess shortnose sturgeon mortality from incidental capture and document characteristics of fisheries that impact shortnose sturgeon (gear types, fishing season and location, fishing effort, etc.)

2.2B* Conduct research to determine sub-lethal effects of incidental capture and provide guidelines to minimize bycatch mortality and sub-lethal effects (i.e. reduce soak times, reduce handling time, gear modification, etc.)

2.2C* Increase enforcement of laws protecting shortnose sturgeon

2.2D* Use cultured fish to develop genetic markers to identify illegally-marketed shortnose sturgeon products

2.3A* Identify and, if prudent, designate critical habitat for shortnose sturgeon population segments

2.3B* Conduct field research to document shortnose sturgeon use of any designated critical habitats and to identify changes in habitat use that would affect critical habitat designations

2.4A* Insure that fish passage devices on all proposed and re-licensed structures allow adequate passage of shortnose sturgeon and do not alter migration or spawning behavior

2.4B* Conduct research to assess the direct and indirect effects of blasting, dredging, and in-river disposal on all life stages of shortnose sturgeon

2.4C* Compare impacts of various dredging, blasting, and disposal techniques and equipment on shortnose sturgeon and their habitat to minimize the detrimental effects of these activities

2.4D* Conduct research to assess shortnose sturgeon mortality from entrainment and impingement and maximize efforts to obtain scientific information from dead fish

2.4E* Analyze shortnose sturgeon tissue, food items, and sediment/water samples from shortnose sturgeon habitat to assess the degree of contaminant loading

2.4F* Determine the effects of contaminants on shortnose sturgeon growth, survival, and reproduction using cultured fish

2.4G* Collect continuous recordings of dissolved oxygen in shortnose sturgeon habitat to identify the extent and duration of hypoxic events

2.4H* Use cultured shortnose sturgeon to determine the species' tolerance for low dissolved oxygen levels under a variety of temperature and salinity conditions and assess the sublethal effects of hypoxia

2.4I* Determine the extent of parasitism, disease, competition for resources, and direct mortality to shortnose sturgeon resulting from introduced species and stock transfers

2.5A* Educate the public and heighten awareness of shortnose sturgeon issues by printing and distributing articles, posters and pamphlets. Make cultured shortnose sturgeon available to aquariums and zoos

2.5B* Update the public on recovery efforts by working with the media to publish articles featuring shortnose sturgeon research and conservation efforts

2.5C* Work with schools to develop and evaluate educational materials and curricula that introduce students to sturgeons, the river/estuarine environment, and the ESA

2.6A* Appoint a Recovery Coordinator and establish regional Recovery Plan Implementation Teams to stimulate implementation of recovery plan objectives among constituents and cooperating agencies

2.6B* Establish a communication network for exchanging research results and highlighting recovery actions

2.6C* Seek funding for shortnose sturgeon recovery activities

2.6D* Complete periodic updates of the Recovery Plan to reflect current status of population segments, factors affecting recovery, and priority recovery objectives

3.1A* In each river, identify natural migration patterns of each life stage and any barriers to movement between habitats. Devise methods to pass shortnose sturgeon above/below existing barriers

3.1B* Examine the relationships between river discharge level (and the correlated bottom water velocity), substrate type, and shortnose sturgeon spawning success

3.1C* Investigate the relationship between spawning substrate characteristics and shortnose sturgeon reproductive success. Conduct field experiments that: (1) evaluate the ability of natural river discharge to remove sediment and debris from spawning substrate; and (2) evaluate the acceptability of artificial substrate to spawning females

3.1D* Restore flows, in regulated rivers, during spawning periods to promote spawning success and rehabilitate degraded spawning substrate

3.1E* Investigate satisfactory methods for examining diet

3.1F* Determine rangewide diet, foraging ecology and growth, for each shortnose sturgeon life stage. In populations with poor growth, examine foraging habitat characteristics and conduct experimental manipulations, if appropriate, to restore habitat

3.1G* If contaminants are directly or indirectly responsible for loss of shortnose sturgeon fitness, identify contaminant or oxygen demanding sources and reduce loading

3.1H* Establish consistent operating policies that allow federal agencies to meet their goals while protecting shortnose sturgeon and their habitats

3.2A* Develop a Shortnose Sturgeon Breeding and Stocking Protocol

3.3A* Use the standardized sampling protocol (1.1E*) to determine whether re-introductions may be needed

3.3B* Determine minimum population size below which restoration may be considered

3.3C* Monitor survival, movement patterns, distribution, foraging, and reproduction of stocked shortnose sturgeon. Use this information to evaluate the success of population restoration

3.4A* Assess the need for augmenting shortnose sturgeon population segments with stocked fish

IMPLEMENTATION SCHEDULE

The Implementation Schedule for the Shortnose Sturgeon Recovery Plan is summarized in the following two relational tables (Table 5 and 6). The first matrix (Table 5) lists all recovery tasks described in the Recovery Objectives section and identifies the agencies with primary responsibility for conducting each task. Cost estimates and probable duration are provided for each task, even though these figures may vary widely depending on where tasks are conducted and if tasks can be combined. Recovery tasks that must be conducted for each population segment or group of population segments are listed in Table 6 and referenced in the "priority" column of Table 5. The priority ranking assigned to each recovery task was based on NMFS Recovery Planning Guidelines, which defines the established priority system (55 FR 24296). Priority 1 tasks are actions "that must be taken to prevent extinction or to identify those actions necessary to prevent extinction." Priority 2 tasks are actions "that must be taken to prevent a significant decline in population numbers, habitat quality, or other significant negative impacts short of extinction." Priority 3 tasks are "all other actions necessary to provide for full recovery of the species."

Many recovery tasks for the Penobscot, Chesapeake, Satillla, St. Marys, and St. Johns population segments are missing priority rankings because very little is known about the status of these population segments. More research on these populations is needed to make an informed assessment of any major threats affecting them and other critical information needs.

Table 5. IMPLEMENTATION SCHEDULE FOR SHORTNOSE STURGEON RECOVERY TASKS

Priority	Task Description	Duration	Responsible Party	Cost: FY1	FY2	FY3	FY4	FY5	Comments
1	1.1 A Conduct a rangewide genetic assessment	ongoing	NMFS, ASMFC, NBS, States, FWS	100 K	100 K	100K	80 K	80 K	Costs/duration may be less if tissue from all populations is available
1	1.1 C Determine endangered & threatened size thresholds	ongoing	NMFS	30 K					May be determined regionally or by river system
1	1.1 E Develop standardized sampling protocol	ongoing	NMFS	15 K					
1	1.1 F Survey where shortnose sturgeon historically occurred	ongoing in some systems	NBS, NMFS, States, ACOE, FERC, FHWA	?	?	?	?	?	Costs will depend on the number of systems surveyed
1	2.1 C Insure that federal actions do not jeopardize sturgeon	ongoing	NMFS						ESA section 7 consultation, costs depend on proposed actions
Table 6	1.1 B Determine abundance, age structure & recruitment	ongoing	EPA, FERC FHWA, NBS, ACOE, NMFS	?	?	?	?	?	Cost/duration depend on river system, and work already done.
Table 6	1.1 D Conduct status reviews	ongoing	NMFS						No cost. In house NMFS review
Table 6	1.2 A Document distribution & map concentration areas	2 years each	EPA, FWHA, NBS, ACOE, FERC, NMFS	50 K each	50 K each				Conduct with tasks 1.2B, 1.2C, 2.3A
2	1.2 B Use cultured fish to study sturgeon biology	3 years	NBS, NMFS, FWS, States	80 K	80 K	80 K			
2	1.2 C Develop criteria to identify essential habitat	2 years	NMFS						To be conducted in house based on 1.2A and 1.2B
Table 6	1.3 A Assess mortality factors & define take limits	5 years each	NMFS, NBS, States	20 K each	20 K each	20 K each	20 K each	20 K each	Costs primarily associated with assessing mortality factors
2	2.1 B Encourage federal agencies to	ongoing	NMFS						Recovery Coordinator Task

Priority	Task Description	Duration	Responsible Party	Cost: FY1	FY2	FY3	FY4	FY5	Comments
	support conservation programs								
Table 6	2.2 A Assess mortality from incidental capture	ongoing	ASMFC, FWS, States, NMFS	20K each	20 K each	20 K each	20 K each	20 K each	May be conducted regionally
2	2.2 B Research & reduce sub-lethal impacts of incidental take	3 years	NMFS, ASMFC, States, NBS, FWS	50 K	50 K	50 K			May be combined with 2.2A to reduce costs
2	2.2 C Increase enforcement of laws	ongoing	ASMFC, FWS, States, NMFS						No cost estimate.
2	2.2 D Develop genetic markers	2 years	FWS, NMFS, States	60 K	60 K				
Table 6	2.3 A Identify critical habitat for population segments	2 years each	NMFS, FWS, NBS, States	50 K each	50 K each	50 K each			Cost is for mapping
Table 6	2.4 A Insure that proposed structures provide passage	ongoing	ACOE, FHWA, FERC, NMFS, FWS	?	?	?	?	?	Costs will depend on modifications needed
2	2.4 B Assess impacts of blasting, dredging,& disposal	3 years	ACOE, FHWA, DOT, NMFS, FWS	100 K	100 K	100 K			may cost more depending on methods tested
Table 6	2.4 D Assess mortality from entrainment & impingement	2 years each	FERC, NRC, NMFS, FWS	80 K each	80 K each				
Table 6	2.4 E Analyze contaminant loads in sturgeon tissue & habitat	3 years each	EPA, States, NMFS, FWS	100 K each	100 K each	100 K each			Costs may be reduced if samples are collected from more than one river
2	2.4 F Determine effects of contaminants on sturgeon fitness	5 years +	EPA, States, NMFS, FWS	100 K	100 K	100 K	100 K	100 K	Long term fitness may be difficult to determine, use doses from 2.4E
Table 6	2.4 G Collect continuous dissolved oxygen data	ongoing	States, FERC, NMFS, EPA, ACOE,	30 K each	30 K each	30 K each			May be combined with other studies to reduce costs
2	2.4 H Assess sturgeon tolerance of low dissolved oxygen	ongoing	EPA, NMFS, FWS, ACOE, States	60 K each	60K each	60 K each			Use biologically relevant doses as determined in 2.4G

Priority	Task Description	Duration	Responsible Party	Cost: FY1	FY2	FY3	FY4	FY5	Comments
2	2.6 C Seek funding for recovery activities	ongoing	NMFS						Recovery Coordinator Task
Table 6	3.1 A Identify movement patterns & devise methods for passage	3 years each	NMFS, ACOE, FERC, FWHA, FWS	60 K each	60 K each	60 K each			Costs may be much greater if barriers must be removed
2	3.1 B Assess effects of river discharge on spawning success	3 years	FERC, ACOE, NBS, NMFS, FWS	60 K	60 K	60 K			Costs may be reduced by combining with 3.1C
2	3.1 C Assess effects of substrate on spawning success	3 years	FERC, ACOE, NBS, NMFS, FWS	60 K	60 K	60 K			Costs may be reduced by combining with 3.1B
2	3.1E Investigate methods for examining sturgeon diet	ongoing	NBS, NMFS, States	20 K	20 K				Can be conducted on a regional basis with 3.1F
2	3.1 F Document diet, foraging ecology, and growth	5 years	NBS, NMFS, States	50 K	50 K	50 K	50 K	50 K	Conduct regionally with 3.1E
3	2.1 A Establish Cooperative Agreements with states	ongoing	NMFS, States						50 K + may be passed yearly to states
Table 6	2.3 B Assess shortnose sturgeon use of any designated critical habitat	3 years each	All state & federal agencies	50 K each	50 K each	50 K each			
Table 6	2.4 C Minimize impacts of dredging, blasting & disposal	ongoing	EPA, ACOE, NMFS, FWHA, FERC, DOT	100 K each	100 K each	100 K each	100 K each	100 K each	Average yearly cost to federal agencies of altering projects
Table 6	2.4 I Determine effects of introduced species and stock transfers	3 years each	FWS, NMFS, NBS, States	60 K each	60 K each	60 K each			Coordinating with other studies of exotic species may reduce costs
3	2.5 A Educate the public & raise awareness of sturgeon issues	ongoing	all state & federal agencies	10 K	10 K	10 K	10 K	10 K	Recovery Coordinator Task
3	2.5 B Update the public on recovery efforts & status	ongoing	All state & federal agencies	10 K	10 K	10 K	10 K	10 K	Recovery Coordinator Task
	2.5 C Develop sturgeon-related								

Priority	Task Description	Duration	Responsible Party	Cost: FY1	FY2	FY3	FY4	FY5	Comments
3	educational materials for schools	1 year	NMFS	20 K					Recovery Coordinator Task
3	2.6 A Appoint Implementation Team/s & Recovery Coordinator	5 years	NMFS	60 K	60 K	60 K	60 K	60 K	GS13 level & 5 K / year for travel
3	2.6 B Communicate research results & recovery actions	ongoing	All state & federal agencies						Recovery Coordinator Task
3	2.6 D Periodically update plan to reflect changes in recovery	ongoing	NMFS						To be conducted in house by NMFS
Table 6	3.1 D Restore flows & rehabilitate spawning substrate	ongoing	FERC, NMFS, ACOE, States	?	?	?	?	?	Depends on results of 3.1B & 3.1C
Table 6	3.1 G Identify contaminant sources & reduce loading	ongoing	EPA, NMFS, FWS, States	?	?	?	?	?	Cost, duration & priority depend on results of 2.4E & 2.4F
3	3.1 H Allow federal agencies to meet mission goals & protect sturgeon	ongoing	EPA, ACOE, FERC, NMFS						To be conducted in house by NMFS
3	3.2 A Develop a breeding and stocking protocol	ongoing	NMFS						To be conducted in house by NMFS
3	3.3A Assess whether re-introductions should be made	ongoing	NMFS						To be conducted in house by NMFS
3	3.3B Determine minimum population size for restoration	ongoing	NMFS						To be conducted in house by NMFS
3	3.3C Monitor & evaluate success of restoration efforts	5 years each	NMFS, ASMFC, FWS, States	50 K each	50 K each	50 K each	50 K each	50 K each	Culture costs not included
3	3.4 A Assess need for augmentation	ongoing	NMFS						To be conducted in house by NMFS

Table 6. IMPLEMENTATION SCHEDULE: TASK PRIORITIES FOR DISTINCT POPULATION SEGMENTS

Task Description	Saint John	Penobscot	Kennebec	Merrimack	Connecticut	Hudson	Delaware	Chesapeake
1.1 B Determine abundance, age structure & recruitment	done	1	ongoing	1	1	ongoing	ongoing	1
1.1 D Conduct status review			3	3	3	3	3	
1.2 A Document distribution & map sturgeon concentration areas	done	1	ongoing	done	done	ongoing	done	ongoing
1.3 A Assess mortality factors & define take limits	2		2	2	2	2	2	2
2.2 A Assess mortality from incidental capture	2		2	2	2	2	2	2
2.3 A Identify critical habitat for population segments	2		2	2	2	2	2	
2.3 B Assess shortnose sturgeon use of any designated critical habitat	3		3	3	3	3	3	
2.4 A Insure that proposed structures provide passage	2			2	1	3	2	
2.4 C Minimize impacts of dredging, blasting & disposal	2		2	2	2	2	2	
2.4 D Assess mortality from impingement			2	2	2	ongoing	2	
2.4 E Analyze contaminant loads in sturgeon tissue & habitat	2		2	2	2	2	2	
2.4 G Collect continuous dissolved oxygen data			2	2	2	ongoing	2	
2.4 I Determine effects of introduced species	3		3	2	2	2	2	

Task Description	Saint John	Penobscot	Kennebec	Merrimack	Connecticut	Hudson	Delaware	Chesapeake
3.1 A Identify movement patterns & eliminate barriers to movement	done		3	2	1	3	3	
3.1 D Restore flows & spawning substrate			2	1	1	2	2	
3.1 G Identify contaminant sources & reduce loading	2		2	2	2	2	2	

Task Description	Cape Fear	Winyah	Santee	Cooper	ACE Basin Basin B	Savannah	Ogeechee	Altamaha	Satilla	St. Marys	St. Johns
1.1 B Determine abundance, age structure & recruitment	1	1	1	1	1	1	1	1	1	1	1
1.1 D Conduct status review	3	3	3	3	3	3	3	3			
1.2 A Document distribution & map sturgeon concentration areas	1	1	1	1	1	1	1	1	1	1	1
1.3 A Assess mortality factors & define take limits	2	2	2	2	2	2	2	2			
2.2 A Assess mortality from incidental capture	1	1	1	1	1	1	1	1			
2.3 A Identify critical habitat for population segments	2	2	2	2	2	2	2	2			
2.3 B Assess shortnose sturgeon use of any designated critical habitat	3	3	3	3	3	3	3	3			
2.4 A Insure that proposed structures provide passage	2	2	2	2	2	2	2	2			
2.4 C Minimize impacts of dredging,	ongoing	2	2	2	2	1	2	2			

Task Description	Cape Fear	Winyah	Santee	Cooper	ACE Basin Basin B	Savannah	Ogeechee	Altamaha	Satilla	St. Marys	St. Johns
blasting & disposal											
2.4 D Assess mortality from impingement	2	2	2	2	2	2	3	2			
2.4 E Analyze contaminant loads in sturgeon tissue & habitat	2	2	2	2	2	2	2	2			
2.4 G Collect continuous dissolved oxygen data	ongoing	1	1	1	1	1	1	1			
2.4 I Determine effects of introduced species	1	2	2	2	2	1	2	2			
3.1A Identify movement patterns & eliminate barriers to movement	1	1	1	1	1	1	3	3			
3.1D Restore flows & spawning substrate	1	2	2	2	2	2	2	2			
3.1G Identify contaminant sources & reduce loading	2	2	2	2	2	2	2	2			

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Mary Colligan
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Allan Creamer
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Mark Collins
SC Department of Natural Resources

Mike Dadswell
Acadia University

Mark Dryer
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Ron Gilbert
University of Georgia

Jim Hoff
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Thomas B. Hoff
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Alan Huff
Florida Department of Natural Resources

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Micah Kieffer
National Biological Service

Ron Klauda
Maryland Department Natural Resources

Mary Parkin
U.S. Fish and Wildlife Service

Lorna Patrick
U.S. Fish and Wildlife Service

Carl Safina
National Audobon Society

Tom Savoy
Connecticut Department of Marine Resources

Theodore Smith
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John Waldman
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APPENDIX I.

Original Listing Notice for Shortnose Sturgeon
Federal Register 32(48): 4001

APPENDIX II.

Resource Publication 114: Threatened Wildlife of the United States
U.S. Department of Interior, March 1973